DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

GEOLOGICAL SURVEY OF GREAT BRITAIN

THE COUNTRY AROUND MORETON IN MARSH.

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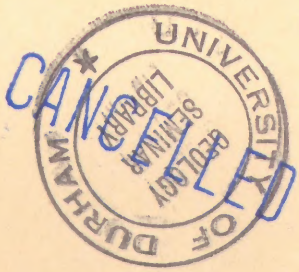

OUTLIERS OF THE COTTESWOLDS—DIXTON AND ALDERTON HILLS, THE FORMER CAPPED WITH MARLSTONE (MIDDLE LIAS), THE LATTER (IN THE CENTRE) WITH UPPER LIAS.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

MEMOIRS OF THE GEOLOGICAL SURVEY ENGLAND AND WALES

EXPLANATION OF SHEET 217

The Country around Moreton in Marsh

By Linsdall Richardson, F.R.S.E.,

With contributions by A. E. Trueman, D.Sc., Daisy M. Williams, M.Sc., R. C. Gaut, M.Sc., and H. G. Dines, A.R.S.M.

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PREFACE

The area included in the New Series One-inch Sheet 217 lies wholly within that of the Old Series Sheet 44, which was surveyed by E. Hull and H. H. Howell and published in Solid only in 1856. A memoir descriptive of this map, by E. Hull, was issued in the following year. Several sections exposed in the Lias and Lower Oolite of the area were subsequently described in the Memoir on ' The Jurassic Rocks of Britain,' by H. B. Woodward (vol. iii, Lias, 1893, and vol. iv, Lower Oolitic Rocks, 1894).

In accordance with the policy of the Geological Survey of replacing the hand-coloured maps by colour-printed editions, New Series Sheet 217 has been issued. Such revision of the geological lines as seemed necessary was carried out, under the supervision of Mr. H. Dewey, by Mr. H. G. Dines, who at the same time made a survey of the Superficial Deposits, the results of which are incorporated in the new map. Mr. Dines has also contributed to the chapter in this Memoir dealing with Superficial Deposits.

Since the days of Murchison (who published his ' Outline of the Geology of the Neighbourhood of Cheltenham ' in 1834) the area of this Sheet has been a field of active research. Murchison's little book was revised and considerably enlarged by H. E. Strickland and James Buckman in 1844. During the latter half of last century this region provided an attractive field for many geologists, among whom should be mentioned Thomas Wright, H. B. Holl and E. A. Walford. The numerous quarries opened in the Oolites offered opportune scope to the late S. S. Buckman for his intensive studies on the zonal subdivisions, based on species of ammonites. Buckman's work, carried out in great detail over a number of years, inaugurated a new era in British Jurassic stratigraphy.

The Superficial Deposits of the area have likewise attracted the attention of several geologists, notably W. C. Lucy of the older school, while in recent years Mr. J. W. Gray has dealt with them in a comprehensive manner.

For the preparation of the present descriptive Memoir the services of Mr. Linsdall Richardson have been enlisted. Mr. Richardson is a well-known authority on the geology of the district and has made many valuable contributions to the literature of the subject. In this Memoir he has made it possible to demonstrate, for the first time, the relationships of the Estuarine deposits of Southern Northamptonshire and Northern Oxfordshire to the predominantly marine Inferior Oolite of the Cotteswolds. Mr. Richardson has brought recent work on the detailed stratigraphy of the Lower Lias under review by including a critical account, by Dr. A. E. Trueman and Miss D. M. Williams, of the Lower Lias ammonites and their zonal distribution. In dealing with the section on Agriculture, Mr. Richardson has availed himself of the expert services of Mr. R. C. Gaut, while Mr. C. C. Duncan has contributed a table of analyses of Soils from the Evesham district.

This Memoir is intended to provide a general account of the present state of our knowledge and to serve as a guide both to the regional geology and to the history of investigation.

For permission to reproduce certain illustrations we wish to express our thanks to the Cotteswold Naturalists' Field Club and to Dr. F. B. A. Welch, whose excellent photographs have been of great assistance to Mr. Richardson.

JOHN S. FLETT,
Director.

Geological Survey Office,
28, Jermyn Street,
London, S.W.1.

22*nd May*, 1929.

CONTENTS

	PAGE
PREFACE BY THE DIRECTOR	iii
LIST OF ILLUSTRATIONS	v
CHAPTER I.—INTRODUCTION: Area and Location, Physical Features, List of Formations, Concealed Rocks and Tectonic Structure	1
,, II.—LIAS	11
,, III.—INFERIOR OOLITE	35
,, IV.—FULLERS' EARTH	84
,, V.—GREAT OOLITE	102
,, VI.—SUPERFICIAL DEPOSITS: Vale of Evesham—Cheltenham, Vale of Moreton, The Uplands; Gravels; Alluvium; Landslips	121
,, VII.—ECONOMIC GEOLOGY: Agriculture, Building Materials, Road Metal, Water	137
APPENDIX I.—LIST OF GEOLOGICAL SURVEY PHOTOGRAPHS IN SHEET 217	156
INDEX	159

ILLUSTRATIONS

PLATES

PLATE I.—Outliers of the Cotteswolds—Dixton and Alderton Hills, the former capped with Marlstone (Middle Lias); the latter (in the centre) with Upper Lias ... *Frontispiece*

FACING PAGE

,, II.—A.—Exposure of Inferior Oolite on Cleeve Cloud: Lower Freestone and Pea Grit Series

B.—Exposure of Inferior Oolite on Cleeve Cloud: Lower Freestone (including obliquely-bedded Polyzoa Beds) resting on Pea Grit 46

,, III.—A.—Holt Quarry, 1 mile west of Blockley: Lower part of the Tilestone, locally sandy, resting on Snowshill Clay

B.—Sand Hole, Cleeve Hill, about 3 miles W.S.W. of Winchcomb: Lower Trigonia Grit, Snowshill Clay, and Harford Sands 50

,, IV.—A.—Guitinghill Quarry, 1 mile W. by N. of Condicote Church: Chipping Norton Limestone

B.—Coscombe Quarry south-east of Stumps Cross, 1½ miles S.E. by S. of Stanway Church: Massive 'Yellow Guiting Stone' 92

,, V.—A.—Railway-cutting between Leckhampton and Charlton Kings stations: Cheltenham Sands (superficial) resting on Lower Lias clay

B.—Railway-cutting between Leckhampton and Charlton Kings stations: Cheltenham Sands (superficial) resting on Lower Lias clay—close view showing details of Cheltenham Sands 124

,, VI.—A.—The Cotswold Slate Company's pit, Eyford Hill: Stonesfield Slate Series—slabs laid out for 'frosting'

B.—The Cotswold Slate Company's Pit, Eyford Hill: Stonesfield Slate Series—slabs stacked ready for transport 144

Figures in Text

PAGE

Fig. 1.—Sketch-map of the geology of the district 3

,, 2.—Diagram to illustrate the comparative developments of the Armatum and Raricostatum Zones of Cheltenham and Radstock 23

,, 3.—Guitinghill Quarry, 1 mile W. by N. of Condicote Church: Chipping Norton Limestone 93

,, 4.—Section of Great Oolite Series, Hampen Railway-cutting ... 103

,, 5.—Section of Taynton Stone and Stonesfield Slate Series in Stanborough Lane Quarry 111

,, 6.—The Cotswold Slate Company's pit, Eyford Hill: Stonesfield Slate Series 115

,, 7.—Geological sketch-map of the district around Condicote ... 116

,, 8.—Sketch-map of the North Cotteswold area, showing the Superficial Deposits 122

,, 9.—Diagrammatic section showing the sequence of Superficial Deposits in the Vale of Moreton, as exposed in the gravel-pit 1¼ miles east of Upper Lemington 127

Tables

FACING PAGE

Table A.—Sequence of Ammonite Faunas of the Lower Lias 11

,, B.—Local Succession of Ammonite Horizons in the Lower Lias ... 16

THE COUNTRY AROUND MORETON IN MARSH

CHAPTER I

INTRODUCTION

Area and Location

Sheet No. 217 of the Geological Survey Map on the one-inch scale represents an area of 216 sq. miles and embraces mainly a portion of north-eastern Gloucestershire, but small parts also of Oxfordshire, Warwickshire, and Worcestershire. It contains, in the south-western corner, part of Cheltenham, and, four miles to the north-eastward, the capital of ancient Mercia—Winchcomb ; in the south-eastern portion, Bourton on the Water and Stow on the Wold ; in the mid-eastern portion, Moreton in Marsh ; and, on the northern margin, part of the typical Cotteswold town of Chipping Campden ; while, dotted about, is a host of villages, among which may be mentioned, Blockley, far-famed Broadway, and old-world Stanton.

The district is served by one section of the London, Midland and Scottish Railway, and three sections of the Great Western Railway. The London, Midland and Scottish Railway Section is that between Ashchurch and Evesham, which, together with a portion of the Great Western Railway's Cheltenham-Honeybourne line, serves the north-western vale-portion of the district. The Great Western Railway between Honeybourne and Kingham (*olim* Chipping Norton Junction) (Oxford, Worcester and Wolverhampton Section), serves the north-eastern vale-portion ; while that (Great Western Railway : Banbury and Cheltenham Branch) between Kingham and Cheltenham climbs over the breadth of the elevated Cotteswold Hills and serves the contiguous upland. It will be observed, however, that the arrangement of the Great Western Railway lines is roughly triangular with the apex of the triangle pointing northward, so that there is left a large area within the triangle—especially the ' heart of the North Cotteswolds '—which is difficult of access.

The line between Cheltenham and Honeybourne was completed as recently as 1906 and provides an interesting example of a modern development that is the outcome of geologic structure. Many of

the farmers—especially in earlier days—used to move their cattle from the vale when the pastures on the Lower Lias clay became sodden with winter rains on to the brash-land of the hills. They had their farms near the foot of the hills, sheltered from the keen winds of the upland, and within reach of streams springing from the hill-sides. Cottages sprang up around the large farms and villages thus came into being—Gretton, Hailes, Didbrook, Stanway, Stanton, Laverton, Buckland, Broadway, etc. Even now it is realised that it is an advantage for a farm to have vale and hill grounds. The development of the fruit-growing industry at Toddington led a private owner to contemplate the construction of a railway if one were not otherwise provided. The line shortly afterwards constructed by the Great Western Railway Company, although part of a greater scheme, opened up this fruit-growing district, and had its course influenced by the numerous villages located along the foot of the Cotteswold Hills.

The district with which this memoir is concerned is mainly residential and agricultural: Cheltenham dates its growth from the time of discovery of its Medicinal Waters in 1716; but it has since added to its Spa advantage that of a residential and educational centre; while agriculture has locally developed in what in an extended sense may be called the Vale of Evesham along the lines of fruit-growing and market-gardening. But above all the district is noteworthy for its scenic beauty. From the hill-margins the views outwards are very extensive—westwards, over the Severn Valley and Border Counties into Wales; north-westwards and northwards over the so-called Midland Plain; north-eastwards and eastwards over the Moreton Valley to the historic Edge Hill, and Oxfordshire Downs; while the view from the high ground in the vicinity of Notgrove south-eastwards and southwards is over the gentle downward slope of the Upper Thames vale to the limiting Chalk escarpment. And inwards, in the main hill-mass of the North Cotteswolds, the view is over—for the most part—a basin-shaped, but high-situated, area; undulating, partly arable, partly down-land; deeply-furrowed with dry valleys, and drained by Thames System streams, in whose sheltered valleys nestle many villages whose occupants find employment on the uplands. The buildings, from cottage to mansion, are seldom dissociated from the scenery in the minds of those familiar with the district, so well do they harmonize. On and in the vicinity of the limestone hills the buildings are of stone with mostly high-pitched roofs tiled with Cotteswold 'slats'; away in the vale, of Marlstone rock, brick, and timber with 'brick noggin'—that is, wood frame-wood filled-in with brick. Modern bricks and cement-blocks are, however, making their appearance as building-materials in the vale; but may the day be far distant that sees the introduction of unharmonious red bricks into the grey stone-wall country of the Cotteswold Hills.

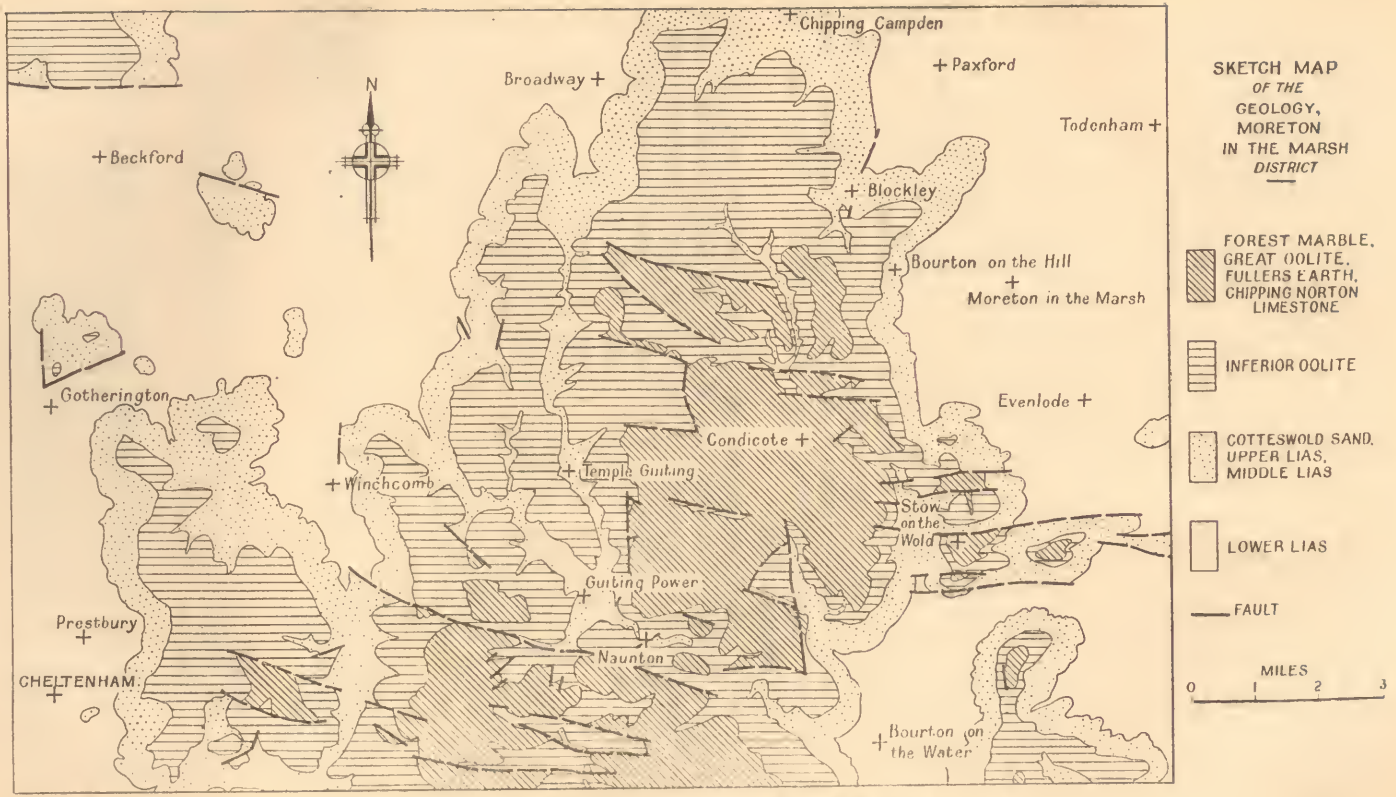

FIG. 1.—*Sketch-map of the Geology, Moreton in Marsh district.*

The local geology is in part of much interest and importance. The Lias has been deprived of much of its attraction to the fossil-collector on account of the present dearth of sections; but the Oolites are exposed in a multitude of quarries, and are of exceptional interest and importance to the student of Jurassic geology in that they furnish facts that materially assist in determining the relationship of the estuarine beds of Southern Northamptonshire and North Oxfordshire to the marine strata of the Cotteswolds.

Physical Features

1. *Relief.*—Broadly speaking, about half the district is in the Severn Basin and about half in the Thames Basin.

Vale-land on the Lower Lias is situate (1) in the north-western portion of the district (Vale of Evesham); (2) along—from north to south—about two-thirds of the eastern portion (Moreton Valley); and (3)—joined by the interesting Maugersbury Valley to the Moreton Valley—toward the south-eastern corner (Vale of Bourton). The first-mentioned vale-land is diversified by the outliers—Bredon Hill (part), Alderton-Dumbleton Hills, Dixton Hill, and the Woolstone-Oxenton Hills.

The main upland embraces the greater part of what has been defined as the North Cotteswolds—that is, that portion of the Cotteswold Hills situate to the north of the Oxford road from Andoversford as far as Little Barrington.[1] The North Cotteswolds are separable into two portions: (1) the Cleeve Hill Plateau, and (2) the main hill-mass. The former portion attains a maximum elevation of 1,070 feet, and is separated from the Mid Cotteswolds to the south by the Chelt Valley and 'Vale of Whittington,' and from the main hill-mass to the east by the deep Charlton Abbots Valley. The latter portion is roughly triangular in plan with the apex of the triangle just outside the district to the north; has high ground along the north-western margin—attaining at Broadway Hill to an elevation of 1,031·3 feet; along the line of the Buckle Street between above Naunton and Cutsdean Hill (1,002·7 feet); and along the eastern margin; but a slight basin-like depression in the heart of the district.

2. *Drainage.*—As already remarked, about half the district is in the Severn Basin and about half in the Thames Basin, and the Severn System is developing to the detriment of the Thames System.

Of the Thames System streams—the River Evenlode drains the southern part of the Moreton Valley; the River Windrush, with

[1] Buckman, S. S. 'The Bajocian of the Mid Cotteswolds,' *Quart. Journ. Geol. Soc.*, vol. li., 1895, p. 389; and 'The Cotteswold Hills: A Geographical Enquiry,' *Proc. Cotteswold Nat. F. C.*, vol. xiv, pt. 3 (1903), p. 223.

the aid of its tributaries the Rivers Dikler and Eye (or, as the latter is locally known in its lower reaches, the ' Slaughter Brook '), nearly the whole of the main hill-mass of the North Cotteswolds north of the Cheltenham and Banbury Line; and the River Coln, the southern part of the Charlton Abbots Valley and contiguous portions of the Cleeve Hill Plateau and main hill-mass.

Of the Severn System streams—the River Stour drains the northern part of the Moreton Valley and the margin of the eastward-facing slope of the North Cotteswolds, and by means of a tributary has made a particularly far-in-reaching incision at Dovedale, Blockley. A traverse from south to north up the Moreton Valley, or a journey along the railway from Moreton in Marsh to Shipston-on-Stour, is instructive in that it crosses the ' divide ' between the Thames and Severn Basins, and reveals a more marked change than might be expected from the comparatively level ground drained by the slow-flowing Evenlode to the markedly furrowed ground drained by the here comparatively steeply-graded Stour.

The northward-flowing River Isbourne (which enters the Stratford Avon at Evesham) drains the northern part of the Charlton Abbots Valley (*per* the Babesmore Brook), the furrowed north-eastern flank of the Cleeve Hill Plateau, and the vale at the foot of the north-westward-facing slope of the main hill-mass of the North Cotteswolds; while the westward-flowing Carrant Brook, with the aid of its tributaries, drains the vale-land that lies between Woolstone-Oxenton, Alderton-Dumbleton, and Bredon (part) Hills.

The River Chelt in this district carries off the drainage of but a small part of the southern portion of the Cleeve Hill Plateau; but is interesting because, according to the laws of river development, it should in due course lengthen headwards (eastwards), and incise and capture the waters (including the Syreford Spring) of the River Coln above Andoversford.

Many particulars in respect of the Rivers Dikler[1] and Eye[2] are of considerable interest, but as these have been recorded already in communications by the writer the necessity of detailing them here is obviated.

Geological Formations

The following formations are distinguished on the colour-printed edition of Sheet 217 of the Geological Survey Map :—

[1] ' The River Dikler,' *Proc. Cotteswold Nat. F.C.*, vol. xxii, pt. 2 for 1925 (1926), pp. 179-181.

[2] ' The River Eye,' *idem*, vol. xxii, pt. 3 for 1926 (1927), pp. 255-258.

	Formation	Age
Superficial	Alluvium, River Gravel, Boulder Clay, Glacial Gravel, Paxford Gravel, Cheltenham Sand and Gravel, Downwash Gravel	Recent and Pleistocene
	Forest Marble	Middle Jurassic
	Great Oolite	
	Fullers' Earth: Fullers' Earth (the local) Upper Estuarine Clay, Neaeran Beds, Chipping Norton Limestone, Roundhill Clay	
	Inferior Oolite	
	Upper Lias: Cotteswold Sands, Upper Lias Clay	Lower Jurassic
	Middle Lias: Marlstone, Sandy Beds	
	Lower Lias	

In the ensuing chapters these formations are described in their ascending order, and certain deposits or accumulations not coloured on the map, namely, ' Granular ' Gravel, Landslips, and Soils (under Agriculture), also receive attention.

Concealed Rocks and Tectonic Structure

The Palaeozoic floor has been reached by a boring at one locality only in the district, namely, at Lower Lemington, about 1 mile north-eastward from Moreton in Marsh. The rocks penetrated have been described by [Sir] Aubrey Strahan,[1] and are as follows :—

Lower Lemington (or ' Batsford ') Boring

(Surface-level :—380 ft. above Ordnance Datum).

	Thickness Ft.	Depth Ft.	Depth, in ft., below O.D. of base of formation
Lower Lias	+418	418	— 38
Rhaetic	48½	466½	— 86½
Upper Keuper Marl	481	947½	— 567½
Lower Keuper Sandstone	74	1,021½	— 641½
Coal Measures	524½	1,546	— 1,166
Silurian	154½	1,700½+	— 1,320½

The Coal Measures consist of sandstones and conglomerates, with grey and red shales and red marls. Coal veins occur in some of the arenaceous beds. Dr. E. A. Newell Arber[2] was disposed to consider

[1] ' Batsford (or Lower Lemington) Boring, near Moreton in Marsh,' ' Summary of Progress ' for 1912 (*Mem. Geol. Surv.*), 1913, p. 90.

[2] The Concealed Oxfordshire Coalfield,' *Trans. Inst. Mining Eng.*, vol. i, pt. 2, 1916, p. 376.

that the beds were his Transition Coal Measures, remarking that they '. . . appear to correspond as regards horizon with the red-grey unproductive 'Transition' Measures of Warwickshire (Haunchwood [Halesowen] Sandstones and Nuneaton Clays [Etruria Marls]) . . .'

About 6½ miles N. by E. from the Lower Lemington Boring is the Armscott Boring.[1] It proved :—

Armscott Boring

(Surface-level :—About 242 ft. above Ordnance Datum).

	Thickness Ft.	Depth Ft.	Depth, in ft., below O.D. of base of U.K.M.
Lower Lias			
Rhaetic	+660	660	
Upper Keuper Marl			−418
Lower Keuper Sandstone	7	667	

Beneath Armscott, therefore, the base of the Upper Keuper Marl is about 149½ ft. higher than it is below Lower Lemington.

A little to the northward of Armscott the Rhaetic White Lias occurs at the surface at an elevation of about 185 ft. above Ordnance Datum.

At 4½ miles W. by S. from the Armscott Boring, however, the Mickleton Boring—which was commenced in the Marlstone of the western face of Ebrington Hill—proved the top of the Rhaetic at about 643 ft. below Ordnance Datum.

Hull[2], as far back as 1855, held that a syncline existed along the 'peninsula of Ebrington Hill,' and remarked that 'it follows almost necessarily that an anticline traverses longitudinally the Vale of Moreton.'

It is a geological axiom that 'once a line of weakness, always a line of weakness.' Hull's inference of an anticlinal line of weakness along the Moreton Valley was found by the late S. S. Buckman[3]—from a study of the distribution of the Inferior Oolite subdivisions—to be a fact. Hull[4] remarked : 'The valley of Bourton on the Water appears to have originated in the existence of an anticlinal traversing its centre from north to south.' Buckman[5] represented the Moreton anticlinal axis as running from north to south *via* Lower Lemington ; between Oddington and Stow on the Wold ; and, down the Vale of Bourton, to Windrush.

The anticline of Palaeozoic rocks along the Moreton axis is probably tilted from north to south.

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[1] At Pool House, Armscott. *See* Richardson, L., 'Boring at Armscott, Worcestershire,' *Trans. Worcestershire Nat. C.*, vol. vii, pt. 4, 1921, pp. 337-339.

[2] 'On the Physical Geography and Pleistocene Phænomena of the Cotteswold Hills,' *Quart. Journ. Geol. Soc.*, vol. xi, 1855, p. 482.

[3] 'Bajocian and Contiguous Deposits in the North Cotteswolds : The Main Hill-Mass,' *Quart. Journ. Geol. Soc.*, vol. lvii, 1901, pp. 140-149.

[4] *Loc. cit.*, 1855, p. 483.

[5] *Loc. cit.*, 1901, pl. vi.

The fall in position of the top of the Rhaetic from 185 ft. above Ordnance Datum at a little to the northward of the Armscott Boring to about 643 ft. below Ordnance Datum at 4½ miles to the W. by S., shows that elevations along the Moreton anticline and depressions in a synclinal area to the west recurred in post-Palaeozoic times.

The course of the main synclinal axis to the west of the Moreton Anticline was from N. by W. to S. by E., through the Cleeve Hill Plateau of which Nottingham Hill is the most northern spur.

Hull[1] remarked that: 'The headland which terminates in Notting [Nottingham] Hill . . . has probably originated in the continuation of a synclinal arrangement of the strata.'

The distribution of the Jurassic rocks in the North Cotteswolds up to and inclusive of the Stonesfield Slate Series demonstrates that the predominant earth-movements in this district were of the nature of elevation along the Moreton Anticline and depression along the Cleeve Hill Syncline.

In addition to these two main axes of elevation and depression there are grounds for concluding that the area contains minor anticlinal and synclinal axes, and little domes and basins: to quote Hull again[2]: 'It therefore appears that, though the strata of the Cotteswold Hills and the valleys by which they are surrounded have a general dip toward the south, yet the district is traversed by a series of gentle rolls, with north and south axes, and that the anticlines have produced lines of weakness, originating valleys; and the synclinals lines of strength, originating headlands.'

A minor anticlinal axis lies along the Winchcomb Valley: Hull[3] remarked: 'The Vale of Winchcomb also appears to present an instance of an anticlinal valley,' and he represented graphically the flexing of the rocks from Nottingham Hill eastward across the Winchcomb Valley by a section in 'The Geology of the Country around Cheltenham' (*Mem. Geol. Surv.*), 1857, fig. 15, p. 99. On or near the line of the northerly continuation of this anticlinal axis, 'in a cutting near Toddington, on the Stow road, on the west bank of the river Isborne,' Thomas Wright,[4] obtained several fossils belonging to the 'Zone of *Ammonites obtusus*,' including '*Ammonites obtusus* Sow,' and '*A. stellaris* Sow.' The presence at the surface here of this zone is proof of the occurrence of an anticlinal flexure.

Hull said:[5] 'I believe there is evidence to prove that the principal headlands [of the hills] are in lines of gentle synclines; while the lateral valleys which bound them run in the directions of anticlinal axes or have a quaquaversal arrangement of the strata.'

[1] *Loc. cit.*, 1855, p. 483.
[2] *Loc. cit.*, 1855, p. 483.
[3] *Loc. cit.*, 1855, p. 483.
[4] *See* p. 15 of this Memoir.
[5] *Loc. cit.*, 1855, p. 482.

Hull had correctly appreciated cause and effect: along the principal anticlinal axes the ultimate covering of Inferior Oolite limestone was thin; but along the principal synclinal axes the deposit preserved was thick. Owing to the thinness of the limestone along the former lines denudation quickly cut through it into the underlying soft Lias clays, originating valleys; but owing to its thickness along the latter lines the rate of denudation was retarded, and headlands originated.

If the courses of the anticlinal and synclinal axes, movements along which affected the distribution of the subdivisions of the Inferior Oolite in the Cotteswold Hills, be studied in conjunction with the Geological Survey Maps, it will be found that where the Oolite is thick—along the synclinal axes, the escarpment runs forward into the vale; but where it is thin—along the anticlinal axes, the escarpment recedes.

A careful consideration of all the facts available leads the writer to record the following information bearing on the probable occurrence of Productive Coal Measures in the main syncline of the North Cotteswolds: the main hill-mass:—

	Thickness Ft.
Upper Lias at Guiting Power	?160
Middle and Lower Lias and Rhaetic in the Mickleton Boring ...	1,274
Upper Keuper Marl in the Lower Lemington Boring, 481 ft., but probably thicker beneath Guiting Power: say... ...	700
Lower Keuper Sandstone at the Warwick Road Boring, Stratford-on-Avon	153
Unproductive Coal Measures in the Warwickshire Coalfield have an estimated thickness of say	4,000[1]
PRODUCTIVE COAL MEASURES	

Conditions in respect of the Coal Measures analogous to those proved by the Lower Lemington Boring on the line of the Moreton Anticline may obtain along the minor Winchcomb Anticline; but along the line of the main Cleeve Hill Syncline it may be suggested that there is a reversion to the position at Temple Guiting with the exceptions that the Lower Lias may be thinner and the Upper Keuper Marl thicker.

No 'solid' rocks are preserved in the district under consideration later than the Forest Marble of Swell Wold, etc. (p. 120). Consequently, no evidence is obtainable in the district of the effects of *post*-? Forest Marble movements along even the main lines of weakness: but, from the limited information bearing on the matter over a wider area that has been collected and published, it appears probable that in later geologic periods fan-like flexing was subordinated to alternating tilting—tilting from N.W. to S.E. being in the ascendancy.

[1] See 'The Geology of the Country around Coventry . . .' (*Mem. Geol. Surv.*), 1923, p. 96.

One effect of these later tiltings on the rocks of the district was described by Buckman:[1] 'The present height of the Marlstone above sea-level is very nearly the same on the west flank of the North Cotteswolds as on the east flank overlooking the Moreton Vale; it is in close approximation to the 600-foot contour-line. But the level of the Upper *Trigonia*-Grit is very different. It is more than 1,000 feet above sea-level on the west flank, and it is about 700 feet above sea-level on the east flank. If then the Upper *Trigonia*-Grit was laid down on a level surface . . . , then at that date the Marlstone dipped westward from the Vale of Moreton, and was some 300 feet lower on the west flank than on the east. The Tertiary elevation of the country brought the Marlstone up to be nearly level, and tilted slightly the Upper *Trigonia*-Grit.'

Faults

Several additional faults—some important—are shown in the Geological Survey Map, New Series, Sheet 217. The evidence for, and comments on, the principal faults delineated on the Old Series Map, Sheet 44, were given by Hull in the explanatory memoir,[2] and it is unnecessary to recapitulate them here. But Hull, in his paper of 1855,[3] gave certain generalizations which are worthy of repetition: they are that there are two systems of faults—N. and S., and E. and W.: "Of the second, the great majority point to 12°N. of W."

"As far as the evidence goes, it tends to prove that the north faults are of earlier date than those at right angles to them, inasmuch as the second are generally terminated by the first. This, however, is a point of much uncertainty . . . . numerically the east and west series greatly exceeds those of other directions."

[1] *Loc. cit.*, 1901, p. 143.

[2] 'The Geology of the Country around Cheltenham' (*Mem. Geol. Surv.*), 1857, pp. 74-82.

[3] *Loc. cit.*, 1855, pp. 486, 487.

TABLE A.—*Sequence of Ammonite Faunas of the Lower Lias*

Oppel's Zones.	Geological Survey Zones.		Ammonite Faunas.	Horizons known in the district
davœi	capricornus / henleyi	HWICCIAN	Oistoceras	x
			daedalicosta	–
			davœi	–
			brevilobatum	x
			lataecosta	x
			Beaniceras	x
			cheltiense	x
			sparsicosta	x
ibex	jamesoni	WESSEXIAN	centaurum	x
			actæon	x
			maugenesti	x
jamesoni			ibex	x
			masseanum	x
			pettos	–
			jamesoni	x
			obsoleta	–
			brevispina	x
			polymorphus	?
			phyllinus	–
			peregrinus	–
			Phricodoceras	x
armatus / raricostatus	armatus / raricostatus	RAASAYAN	leckenbyi	–
			exhaeredatum ...	–
			aplanatum	–
			macdonnelli	–
			nodoblongum	x
			subplanicosta	x
			planum	x
			raricostatoides ...	–
			aeneum	–
			zieteni	–
			ornatilobatum	–
			armatum (with Gleviceras)	x
			bispinigerum	x
			densinodulum ...	x
oxynotus	oxynotus	DEIRAN	lymense...	
			polyophyllum	x
			oxynotum	x
			biferum	x
			simpsoni	–
			gagateum	–
obtusus	obtusus	MERCIAN	lacunata	x
			subpolita	x
			denotatus	x
			stellare	x
			planicosta	–
			sagittarium	x
			obtusum	x
			turneri	x
Pentacrinus tuberculatus / bucklandi	semicostatus / bucklandi	LYMIAN	plotti	–
			birchi	x
			hartmanni	–
			brooki	–
			sulcifer	–
			nodulosum	x
			alcinoe	x
			sauzeanum	x
			pseudokridion ...	–
			scipionianum	x
			acuticarinatum ...	–
			gmuendense	x
			vercingetorix	–
			meridionalis	–
			bucklandi	–
			rotator	x
			conybearei	x
angulatus / planorbis	angulatus / planorbis	HETTANGIAN	angulata (marmorea) ...	x
			liasicus	x
			Psilophyllites	–
			megastoma	x
			johnstoni	–
			planorbis	x
			liassica	x
			tatei	x
			langportensis	x

To face p. 11]

CHAPTER II

THE LIAS

Lower Lias

The Lower Lias has been dug in a number of pits, but at the present time only four are 'in work,' namely, at the Battledown Brick Works, Cheltenham; Winchcomb Brick and Tile Works, Greet; near Blockley Station; and at the Aston Magna Brick and Terra-Cotta Works, Aston Magna.

The table of zones given in Table A has been prepared by Dr. A. E. Trueman and Miss D. M. Williams. In it are summarized recent views of the ammonite succession. It is mainly based on the work of S. S. Buckman on Jurassic Chronology,[1] modified in respect of the results obtained by Dr. W. D. Lang, Dr. L. F. Spath and others.[2] The table shows the general correspondence of the ammonite succession with the zonal divisions formerly used; but complete correlation is impracticable owing to the inadequacy of the original zones.

The ammonite faunas which are represented in the district are indicated thus x. This information has been obtained partly from a study of material collected in the area, but in certain cases from an interpretation of previous records.

For many years previous to 1919 it had been customary to speak of the beds such as were formerly exposed at the now built over Pilley (or Pilford) Brickworks (just outside the district under consideration) as the 'Capricornus Beds,' and those still magnificently displayed in the extensive clay-pit at the Battledown Brick Works (in Coltham Fields) as the 'Striatus Beds' and the 'Valdani Beds.' Some perplexity had existed in the minds of local workers because in certain other districts '*capricornus*-type' of ammonites had been noted below the 'Striatus Beds.' In 1919, however, Dr. A. E. Trueman[3] published the results of his studies on 'The Evolution of the Liparoceratidae,' wherein he demonstrated that the '*capricornus*-

[1] 'Jurassic Chronology—I. Lias,' *Quart. Journ. Geol. Soc.*, vol. lxxiii, 1917, p. 257; 'Jurassic Chronology—I. Lias: 'Supplement 1,' *idem*, vol. lxxvi, 1920, p. 66; 'Type Ammonites,' vol v, 1925, p. 77.

[2] Lang, W. D., and L. F. Spath, 'Shales with Beef,' pts. 1 and 2, *Quart. Journ. Geol. Soc.*, vol. lxxix, 1923, p. 47; 'The Blue Lias of the Devon and Dorset Coasts,' *Proc. Geol. Assoc.*, vol. xxxv, 1924, p. 169: 'The Black Marl of Black Ven and Stonebarrow in the Lias of the Dorset Coast,' *Quart. Journ. Geol. Soc.*, vol. lxxxii, 1926, p. 144; Spath, L. F., 'On the Liassic Succession of Pabay (Inner Hebrides),' *Geol. Mag.*, vol. lix, 1922, p. 548; 'Notes on Yorkshire Ammonites,' *Naturalist*, 1925; Trueman, A. E., and D. M. Williams, 'Studies in the Ammonites of the Family Echioceratidae,' *Trans. Roy. Soc. Edin.*, vol. liii, 1925, p. 699.

[3] *Quart. Journ. Geol. Soc.*, vol. lxxiv, 1918, pp. 247-298.

type ' of ammonite from below the ' Striatus Beds ' was the ancestral form of the ' *striatus*-type ' and defined a definite subzone—that of *Liparoceras sparsicosta* Trueman ; that the ' *striatus*-type ' of ammonite from the vicinity of Cheltenham should be known as *Liparoceras cheltiense* (Murchison) ; that the ' Yellow Lias ' was of *Beaniceras* hemera ; and that the ' Capricornus Beds ' of earlier authors were divisible into Lataecosta and Brevilobatum Subzones.

Local Details

At the locality known locally as ' Ledmores,' on the north side of the Chelt above the ' I ' of Inn west of ' Detmore,' Charlton Kings, clay and limestone nodules of the ' Yellow Lias ' (Beaniceras Subzone) were thrown out when a well was deepened.[1] The nodules were full of fossils which included—*Monodonta modesta* Tate (common), *Chemnitzia liassica* (Quenstedt), *Turbo admirandus* Tate, *Arca stricklandi* Tate, *Cardinia attenuata* (Stutchbury), *Cardita multicostata* (Phillips), *Gervillia laevis* (J. Buckman), *Grammatodon buckmani* (G. F. Richardson), *Gryphaea concava* J. Buckman, *Nuculana galatea* (auctt.), *Limea acuticosta* Münster, *Plicatula spinosa* J. Sowerby, *Rhynchonella fimbria* L. Richardson,[2] *Acrosalenia* (spines), and *Isocrinus* ossicles.

The only place at which Liassic fossils, well preserved and in numbers both as regards species and individuals, can be collected at the present time in the vicinity of Cheltenham is in the large and deep clay-pit of Messrs. Webb Bros. Battledown Brick Works, Coltham Fields. Here the ' Yellow Lias ' (Beaniceras Subzone) and a considerable thickness of the underlying clays (the bulk belonging to the Cheltiense, ' Maugenesti ' (Valdani), and Ibex Subzones) are exposed.

The fossils obtainable here include :—

Name of Species	Underlying clays	' Yellow Lias '	Notes
Ichthyosaurus sp. (*Vertebrae*) ...		*	
Acanthopleuroceras spp.	*		
Beaniceras *cf.* centaurus (*d'Orbigny*)			
,, *cf.* luridum (*Simpson*) ...			
Liparoceras cheltiense (*Murchison*) ...	*		
Tragophylloceras boblayei (*d'Orbigny*)	*		
,, ibex (*Quenstedt*) ...	*		
,, wechsleri (*Oppel*) ...	*		
Belemnites spp	*		
Nautilus pseudotruncatus *Crick* ...	*		*Proc. Cotteswold Nat. F.C., vol.* xx, pt. 3, for 1920 (1921), p .245.
,, striatus *J. Sowerby* ...	*		
Amberleya imbricata (*J. Sowerby*) ...	*	*	
Exelissa numismalis *Tate*	*	*	
Pleurotomaria anglica (*J. Sow.*) ...		*	
Cf. Trochus cyclostoma (*Benz*) ...		*	
Turbo admirandus *Tate*	*	*	

[1] Richardson, L., ' Memoir Explanatory of a Map . . . (6-inch Series xxvi., S.E.),' *Proc. Cotteswold Nat. F.C.*, vol. xviii, pt. 2, 1913, p. 127.

[2] Richardson, L., ' A Handbook to the Geology of Cheltenham,' 1904, pl. xv., figs. *5a-d.*

Name of Species	Underlying clays	'Yellow Lias'	Notes
Dentalium elongatum *Münster* ...	*	*	
,, oblongum *Richardson* ...		*	
,, parvulum *Rich. ex J. Buckman MS.* ...	*		
Arca stricklandi *Tate*		*	=*A. truncata*, J. Buckman in Murchison's 'Outline of the Geology of Cheltenham,' new ed. by H. E. Strickland and J. Buckman, 1844, t. 10. f. 6,
Cardinia attenuata (*Stutchbury*) ...		*	Richardson, L., 'A Handbook to the Geology of Cheltenham . . .,' 1904, pl. xv., f. 10.
Gervillia laevis (*J. Buckman*) ...		*	1844, t. 10, f. 8, p. 98.
Grammatodon buckmani (*G. F. Richardson*)		*	1904, pl. xv, f. 9.
Gryphaea concava *J. Buckman* ...		*	1844, p. 98.
Hippopodium ponderosum (*J. Sow.*)		*	
Inoceramus ventricosus (*J. de C. Sow.*)	*	*	1904, pl. xv, f. 6.
Modiola ? numismalis *Oppel*		*	
,, *aff.* scalprum (*J. Sow.*) ...		*	
Pecten (Chlamys) *aff.* priscus *Schlotheim*		*	
,, (Entolium) substriatus *Roemer*	*		
Pinna folium (*Young & Bird*) ...		*	
Pteria longiaxis (*J. Buckman*) ...		*	1844, t. 10, f. 2, p. 97.
Arcomya elongata (*Roemer*)		*	1904, pl. xix, f. 2*a-b*. = *Sanguinolaria striata* J. Buckman, 1844, tab. 10, f. 10, p. 100.
Unicardium cardioides *Phillips* ...	*	*	
Rhynchonella fimbria (*Quenstedt*) ...		*	1904, pl. xv, f. 5*a-d*.
Spiriferina punctata (*J. Buckman*) ...		*	1844, t. 10, f. 7, p. 100.
Terebratula subovoides *Roemer* ...		*	1904, pl. xv, f. 8.
Zeilleria *cf.* perforata (*Piette*) ...		*	
Ditrupa quinquesulcata (*Münster*) ...	*	*	
Isocrinus	*	*	

The Harp Hill, Shakell's (or Shackel's) Pike, or Cemetery Road clay-pit, is now occupied by a nursery-garden. The clays last dug here were of hemera *valdani*, and fragments of *Acanthopleuroceras spp.* abounded. In earlier days, higher beds—the Cheltiense and Capricornus Beds—were worked.

Thomas Wright recorded[1] that 'Beds of laminated shales and ferruginous clays, the equivalent in age to those at Mickleton [Tunnel; his 'Zone of *Aegoceras Henleyi*'], were exposed in making excavations at Hewlett's Hill for the reservoirs of the Cheltenham water-works; many of the ironstone

[1] 'Monogr. Lias Ammonites,' (*Palaeontographical Society*), 1879, p. 87.

bands were full of fossils in various stages of decay, from the decomposition of the calcareous matter of the shell.'

At Queen's Wood Cottages, Prestbury, very fossiliferous beds belonging to the Sparsicosta Subzone were proved in a well. The fossils obtained included *Liparoceras sparsicosta* Trueman[1], *Amberleya imbricata* (J. Sowerby), *Astarte* aff. *dentilabrum* Etheridge (very abundant), *Cucullaea intermedia* (Simpson), *Gervillia laevis* (J. Buckman), *Grammatodon buckmani* (G. F. Richardson), *Inoceramus ventricosus* (J. de C. Sowerby), *Pholadomya ambigua* (J. Sow.), *Pinna folium* (Young and Bird), *Pleuromya costata* (Y. & B.), *Unicardium globosum* Moore, and *Ditrupa quinquesulcata* (Münster).

T. Wright noted the following section at the now abandoned and overgrown Marle Hill[2] or Folly Lane Brickyard, Cheltenham :—

	Ft.	Ins.
'*Gryphaea-bed* ; a hard ferruginous clay, . . . with a great many specimens of *Gryphaea obliquata* Sow.	3-4	0
Coral-band ; . . . *Montlivaltia rugosa* Wr	1 in.-0	1½
Hippopodium-bed ; a stiff dark-coloured clay . . . containing *Cardinia Listeri*, Sow., and *Hippopodium ponderosum* Sow., in considerable numbers ... ... from	8-10	0
Ammonite-bed ; a dark, ferruginous clay, . . . *Aegoceras subplanicosta*, Opp. [=*Microceras subplanicosta* and other species], *Aegoceras densinodum* [=*Metaderoceras spp.* and *Crucilobiceras spp.*], *Arietites raricostatus* [an Echioceratid] *Arietites Notidianus* [=*Plesechioceras sp.*]	Not ascertained.	

and said :[3]—' At [Bishop's] Cleeve[4] . . . the same beds were formerly worked for brickearth ; and the finest specimens of *Cardinia Listeri*, Sow., *Hippopodium ponderosum*, Sow., *Arietites raricostatus* Zieten and *Pleurotomaria similis* [*anglica*], Sow., were obtained from here.'

In 1902, in drain-excavations near the gravel-pit (see p. 33) at Overbury, a fine specimen of *Oxynoticeras oxynotum* (Quenstedt) was found, while a little higher up the road examples of *Deroceras armatum* (J. Sowerby) were obtained.[5]

Near Didcot Farm, west of Dumbleton Hill, there was formerly a clay-pit. The beds consisted of blue and brown clays with many ironstone-nodules, cement-stones of a grey tint, and masses of shelly limestone. A large number of fossils was obtained by Mrs. Hutton (*née* Holland). The specimens were named by Wright[6], and included '*Ammonites Henleyi*, Sow., *A. capricornus*, Schloth., *A. loscombi*, Sow., and *A. fimbriatus*, Sow.' Wright identified the deposit as ' The Zone of *Ammonites capricornus*.' The pit has now been long abandoned, but Dr. A. E. Trueman has ascertained from a study of the ammonites—which include *Liparoceras* aff. *heterogenes* (Young & Bird)—that the same subzone, namely, that of *Liparoceras sparsicosta* Trueman, as was pierced by the well at Queen's Wood Cottages is present here.[7]

At two-fifths of a mile N. by W. of Alderton Church the writer obtained from a temporary excavation a fragment of *Tragophylloceras boblayei* (d'Orbigny).

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[1] Holotype. A. E. Trueman, ' The Evolution of the Liparoceratidae,' *Quart. Journ. Geol. Soc.*, vol. lxxiv, 1918, p. 265, pl. xxi, fig. 2.

[2] ' Monogr. Lias Ammonites,' *Palaeontographical Society*, 1879, p. 55.

[3] *Idem*, p. 56.

[4] Indications of old clay-pits are to be seen close to the road from the village to the station, and between the village and the Farmers' Arms.

[5] Richardson, L., ' Notes on the Geology of Bredon Hill,' *Trans. Woolhope Nat. F.C.*, for 1902, p. 67.

[6] ' Report on Miss Holland's Collection of Lias Fossils,' *Proc. Cotteswold Nat. F.C.*, vol. iii [1862], pp. 153-155.

[7] ' The Evolution of the Liparoceratidae,' *Quart. Journ. Geol. Soc.*, vol. lxxiv, 1919, p. 252.

T. Wright[1] collected ' . . . in a cutting near Toddington, on the Stow road, on the west bank of the river Isborne, . . . several fossils belonging to the Zone of *Ammonites obtusus* . . .' They were :—' *Ammonites obtusus*, Sow. Two very good specimens. *A. stellaris*, Sow., *Nautilus striatus* Sow., *Gryphaea incurva*, Sow., *Ostrea* (nov. sp.).'

The Brickworks at Greet, 1 mile north of Winchcomb, were closed in 1904, but have been re-opened as the Winchcomb Brick and Tile Works. The clays now dug are dark and loamy, weathering grey, and contain grey cement-stones. Examples of *Inoceramus ventricosus* (J. de C. Sowerby), *Pinna folium* (Young & Bird), and *Unicardium cardioides* Phillips have been obtained from the re-opened clays ; but no ammonites. In his ' Handbook to the Geology of Cheltenham . . .', p. 46, the writer stated that ' The *striatum*-beds were formerly worked at Greet,'[2] and it may be that the Sparsicosta Subzone is present.

In 1925 Captain E. G. Spencer Churchill of Northwick Park, Blockley, opened a Brick Works near Blockley Station to make bricks for developing his Harrow on the Hill Estate. No ammonites were found : only *Belemnites clavatus* Blainville, *Amberleya imbricata* (J. Sowerby), and isocrinoid ossicles, but these suggest a date of late hemera *valdani* for the clay.

At the Aston Magna Brick and Terra-Cotta Works there is a fine section of the Capricornus Beds in which fossils—including *Amblycoceras sp.*—are very abundant.[3]

About the year 1901 a pit was opened about ½ mile away to the south-east of the Aston Magna Works at Leighswood in the blue clays of the Raricostatum and basal Armatum Zones ; but the presence of limestone-nodules and the distance from the railway combined to render the project unprofitable and the works were abandoned. The clays here contained *Gryphaeae*, belemnites not uncommonly, small examples of *Microceras subplanicosta* (Oppel), and *Unicardium cardioides* (Phill.) ; while the limestone-nodules yielded the same species, and, in addition, specimens of *Microceras* cf. *nodoblongum* (Quenstedt) and *Actaeonina whitfieldi* (Moore).[4]

Near to is the railway-cutting in the Raricostatum, Armatum, Jamesoni, and probably Valdani Zones, whence G. E. Gavey and T. J. Slatter obtained so many interesting fossils. The banks of the cutting are now quite overgrown, but the geological information that was obtained was satisfactorily recorded by Gavey,[5] and many of the fossils that were collected here by Slatter were examined by Ralph Tate.[6] As H. B. Woodward remarked,[7] these fossils constitute an ' assemblage that may be paralleled with that obtained from the Zone of *Ammonites Jamesoni*, etc., by Mr. Beesley at Fenny Compton,' and it may be added, with that which has been obtained from the railway-cutting at Toddington (see p. 20).

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[1] *Proc. Cotteswold Nat. F.C.*, vol. iii, p. 153.

[2] See also Richardson, L., and R. J. Webb, ' Brickearths, Pottery and Brickmaking in Gloucestershire,' *Proc. Cheltenham Nat. Sci. Soc.*, N.S., vol. i, pt. 4, 1910, p. 273.

[3] Richardson, L., ' On the Lias Sections at Aston Magna, Worcestershire,' *Trans. Worcestershire Nat. C.*, vol. iv, pt. 4 for 1910, pp. 401-403 ; Richardson, L., and R. J. Webb, ' Brickearths, Pottery and Brickmaking in Gloucestershire,' *Proc. Cheltenham Nat. Sci. Soc.*, N.S., vol. i, pt. 4, 1910, pp. 275, 276.

[4] Richardson, L., *Trans. Worcestershire Nat. F.C.*, vol. iv. pt. 4 for 1910, p. 401 ; ' Excursion to the Vale of Evesham and the North Cotteswolds,' *Proc. Geol. Assoc.*, vol. xviii, pt. 8, 1904, p. 406 ; *Proc. Cheltenham Nat. Sci. Soc.*, N.S., vol. i, pt. 4, 1910, p. 276.

[5] ' On the Railway Cuttings at the Mickleton Tunnel [Glos.], and at Aston Magna . . . Worcs.), *Quart. Journ. Geol. Soc.*, vol. ix, 1853, pp. 35-36.

[6] ' On the Palaeontology of the Junction Beds of the Lower and Middle Lias in Gloucestershire,' *Idem*, vol. xxvi, 1870, pp. 396-399.

[7] ' Jurassic Rocks of Britain ' (*Mem. Geol. Surv.*), vol. iii, 1893, p. 154.

From the well at the lodge for Lower Swell Manor, between Stow on the Wold Station and the town, pieces of rock, literally made up of the dismembered joints of *Isocrinus* (as in the Capricornus Beds of Aston Magna), were excavated.

H. B. Woodward says :[1] "A large collection of fossils was obtained by the Rev. S. Lucas[2] from the cutting on the Banbury and Cheltenham Railway at Maugersbury, near Oddington. The Zone of *Ammonites Henleyi* and other beds were exposed, but the horizons of the fossils recorded are not indicated."

The following fossils were collected by the writer from the ' Yellow Lias ' limestone-nodules of a cutting through ' Stow Hill ' :—*Cardinia attenuata* (Stutch.), *Modiola* aff. *scalprum* (J. Sow.), *Pinna folium* Y. & B. and *Unicardium cardioides* (Phill). Probably this cutting through ' Stow Hill ' is the same as Lucas's cutting ' in the railway, near Oddington, near Stow-on-the-Wold,' and the fossils mentioned as being in my possession most likely came from his bed—' an irregular band of limestone, generally formed of a mass of shells.'

A specimen of *Cardinia attenuata* (Stutch.), indicating the presence of ' Yellow Lias,' has been obtained at Wyck Rissington.

When the Cheltenham-Honeybourne Railway (G.W.R.) was constructed in 1902—1906 numerous cuttings and a tunnel (Greet) were made in the Lower Lias and a large number of fossils was collected. The writer has described the geology of the line and given lists of the fossils collected.[3] Owing to the method of making the cuttings, namely, by steam-navvies, nearly all the fossils had to be collected from the weathered clay on the sloped sides of the cuttings. In 1920 S. S. Buckman discussed the ammonite records and gave his views as to their significance.[4] The ammonites preserved by the writer have been re-examined by Dr. A. E. Trueman and Miss D. M. Williams, and their results are appended. More particulars are not given because all the cuttings are now overgrown, and for information on certain of the fossils the reader is referred to papers that have appeared.[5]

Ammonite horizons of the Lower Lias exposed in the cuttings of the Cheltenham-Honeybourne Railway

By A. E. Trueman and Daisy M. Williams

An account of the faunas collected by Mr. L. Richardson in the cuttings of the Cheltenham-Honeybourne railway was published in 1918[6]. Subsequently S. S. Buckman[7] used the facts noted by Mr.

[1] *Idem*, p. 157.

[2] ' Section of the Lias Clay in a railway-cutting near Stow-on-the-Wold,' *Geologist*, vol. v, 1862, pp. 127, 128.

[3] ' The Geology (Lias and Superficial Deposits) of the Cheltenham-Stratford-on-Avon Railway (G.W.R.).' *Trans. Woolhope Nat. F.C.* for 1916 (1918), pp. 137-153.

[4] ' Jurassic Chronology : Lias, Supplement I.' *Quart. Journ. Geol. Soc.*, vol. lxxvi, 1920, pp. 62-103.

[5] Richardson, L., ' Liassic Dentaliidae ' *Idem*, vol. lxii, 1906, p. 573-595 ; S. S. Buckman, ' Some Species of the Genus *Cincta*,' *Proc. Cotteswold Nat. F.C.*, vol. xvi, pt. 1, 1907, pp. 41-63 ; A. E. Trueman, ' The Evolution of the Liparoceratidae,' *Quart. Journ. Geol. Soc.*, vol. lxxiv, 1918, pp. 247-298 ; A. E. Trueman and D. M. Williams, ' Studies in the Ammonites of the Family Echioceratidae,' *Trans. Roy. Soc. Edin.*, vol. liii, 1925, p. 734 ; A. E. Trueman and D. M. Williams, ' Notes on some Lias Ammonites from the Cheltenham District,' *Proc. Cotteswold Nat. F.C.*, vol. xxii. 1926, pp. 239-253.

[6] ' The Geology (Lias and Superficial Deposits) of the Cheltenham-Stratford-on-Avon Railway (G.W.R.).' *Trans. Woolhope Nat. F.C.*, 1916 (1918), pp. 137-153.

[7] ' Jurassic Chronology : Lias, Supplement I.' *Quart. Journ. Geol. Soc.*, vol. lxxvi, 1920, pp. 62-103.

TABLE B.—*Local Succession of Ammonite Horizons in the Lower Lias*

HORIZON [The sequence in some parts is hypothetical]	Bayliss Hill	Weston Subedge	Broadway	Stanton Fields	Toddington	Didbrook	Hailes	Isbourne	Greet	Dixton East	Dixton West	Gotherington	Bishop's Cleeve	Evesham Road	Hunting Butts N.	Hunting Butts S.	Chestnut Farm	St. George's Road
brevilobatum											x							
lataecosta									x	x		x						
Beaniceras																		
cheltiense						x			x	x	x	x						
Horizons with Acanthopleuroceras *and* Tragophylloceras ...						x	x				x							
							x				x							
Horizon with Polymorphites bronni ...								x					x					
Various horizons with Uptonia, Platypleuroceras, *etc.* *mostly unrepresented*					?		?	?					?					
leckenbyi					—GAP—								—GAP—					
exhaeredatum																		
aplanatum																		
macdonnelli																		
nodoblongum { Leptonotoceras spp. ? ...	x		?	x	x													
nodoblongum { Deroceras sp. juv.-*unispinous form*					x											x		
nodoblongum { Metaderoceras *cf.* nodoblongum, *etc.* ...	x		x	x									?	?		x		
nodoblongum { Deroceras *cf.* miles ...	x				x													
subplanicosta	x	x	x	x												x	x	x
Paracymbites			x	x	x										x		?	
planum { Leptechioceras planum ...														x				
planum { Crucilobiceras sp. nov. ...														x	x			
planum { Deroceras spp.														x	x			
planum { Plesechioceras spp.	x	?	—GAP—											x	x			
raricostatoides	—GAP—			—														
aeneum				GAP														
zieteni				—														
ornatilobatum			—GAP—															
armatum	?		?															
bispinigerum			?															
densinodulum																		
lymense																		
polyophyllum and oxynotum ...			x	x														

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[7] 'Jur
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Richardson to amplify his interpretation of the ammonite sequence within the zones that were exposed. Partly as a result of these studies Buckman suggested that a number of new horizons could be recognised within the strata that had been called the Oxynotum, Raricostatum, Armatum, Valdani, Striatum, and Capricornus Zones, although not all of these horizons were to be found in the area dealt with. A revised interpretation of the sequence was published in 1925[1]; this forms the basis of Table B facing p. 16, but this has been modified in accordance with more recent views. In that table the horizons (some of which have perhaps no more than a local value) are named alongside the zonal terms, but it may be noted that, as the new terms represent an expansion of the sequence and not a subdivision of the earlier zones, any exact correlation of the terms is not possible.

More recently evidence has accumulated which suggests that Buckman's interpretation of the ammonite sequence in these cuttings is not in accordance with all the facts. In the first place, from a study of the material collected by Mr. Richardson, the present writers have concluded that the names used by Mr. Buckman and Mr. Richardson are inadequate for the faunal analyses that have been based on them. For instance, it is considered that the '*Echioceras*' faunas present in the area were related to those of the *macdonnelli* (and *planum*) horizons rather than to the '1st *Echioceras*.'[2] Further, many of the forms referred to as *Deroceras spp.* may now be referred to *Crucilobiceras* and allied genera, while other identifications need considerable revision. Many of the forms are new and have recently been described.[3]

The distribution of the ammonites of some of these horizons has been studied in considerable detail by Dr. W. D. Lang on the Dorset coast. Largely as a result of this work Dr. Spath[4] has determined the sequence of ammonite faunas within the strata formerly called Armatum and Raricostatum Zones. Dr. Spath's interpretation appears to accord fairly closely with the revised sequence that is suggested by our reconsideration of the ammonites from the cuttings of the Cheltenham-Honeybourne railway. Dr. Spath's divisions of the Deroceratan Age,[5] modified in accordance with the authors' views on the lower *Echioceras* faunas, are given below, with the other species regarded by him as characteristic of certain horizons.

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[1] 'Jurassic Ammonites and Chronology,' reprinted from 'Type Ammonites, vol. 5, 1925, p. 77.

[2] Trueman, A. E. and D. M. Williams, 'Studies in the Ammonites of the Family Echioceratidae.' *Trans. Roy. Soc. Edin.*, vol. liii, 1925, p. 734.

[3] A. E. Trueman and Williams, D. M., 'Notes on some Lias Ammonites from the Cheltenham District.' *Proc. Cotteswold Nat. F.C.*, vol. xxii, 1926, p. 239.

[4] Lang, W. D. and L. F. Spath, The 'Black Marl of Black Ven and Stonebarrow in the Lias of the Dorset Coast.' *Quart. Journ. Geol. Soc.*, vol. lxxxii, 1926, p. 144; Spath, L. F., 'Notes on Yorkshire Ammonites. III. The Armatum Zone.' *The Naturalist*, June, 1925.

[5] *Op. cit.* (*Naturalist*, 1925), p. 169.

leckenbyi	
tardecrescens	
macdonnelli	with ? *Tubellites tubellum*, *Metaderoceras nodoblongum*, *M. muticum*, *Deroceras miles*, *Microceras subplanicosta*.
?	
raricostatoides	with large *Gleviceras sp.*
ornatilobatum	with ' carinati-subsulcate *Echioceras.*'
armatum	with *Gleviceras*, *Leptonotoceras leptonotum*, *Deroceras obesum* and other spp.
bispinigerum	with *subplanicosta*-like forms.
densinodulum	with small *Crucilobiceras spp.*, *Deroceras bispinigerum* and *Gleviceras.*

It will be noted that the horizon of *Microceras subplanicosta* is much higher than Buckman supposed ; while species of the genus *Gleviceras* occur at several horizons within the lower part of the Raricostatum Zone.

From the distribution of the ammonite species in the various cuttings, it appears to the writers that the species quoted by Dr. Spath as occurring in the ' Macdonnelli ' Beds must, in this area at least, represent several distinct horizons. The sequence of these cannot be conclusively demonstrated, however, on the evidence before us ; it is certain that horizons with *Leptechioceras planum*, *Plesechioceras*, and various species of *Deroceras* and *Crucilobiceras* underlie horizons with *Microceras subplanicosta*, *Metaderoceras spp.*, *Crucilobiceras* ? *crucilobatum*, *C. spp.*, *Leptonotoceras sp.* and *Deroceras* cf. *miles*.

A *Cymbites*-like form (*Paracymbites obsoletus* Trueman and Williams) is also represented, but the position of this and the relative positions of the horizons named above, can scarcely be determined from the material available.

Below these horizons in several cuttings beds with various oxynotes were exposed, presumably indicating the Oxynotum Zone. There is very little evidence of the faunas of the *densinodulum*, *bispinigerum*, *armatum* and *ornatilobatum* horizons, and no evidence of the *aeneum* and *raricostatoides* horizons.

Notes on Certain Cuttings

Bayliss Hill.—Mr. Richardson's information concerning the ammonites found in this cutting may be summarized as follows :—

1. Blue clay, with *Bifericeras subplanicosta* (Oppel), *Microceras densinodum* (Quenstedt), and *Polymorphites polymorphus* (Quenstedt).
2. Coral Bed, with *Microceras densinodum* (Quenstedt).
3. *Hippopodium*-Bed with *Echioceras raricostatum* (Zieten), *Oxynoticeras guibalianum* (d'Orbigny).

The ammonite called *Echioceras raricostatum* is identified by us as *Euechioceras subobsoletum* (Buckman) and is similar to forms found in a pre-*macdonnelli* horizon in the Radstock district ; *Plesechioceras* is also present. The oxynote ammonite called *O. guibalianum* (d'Orbigny) by Mr. Richardson

was interpreted as a species of *Gleviceras* by Buckman,[1] but as we have not seen the specimen we are unable to go further than this identification. Associated with it are finely-ribbed Echiocerates (*Plesechioceras* cf. *schlumbergeri* (Reynès) and allied forms). The Echioceratids from this and other cuttings are of a yellowish brown colour, and from their preservation would appear to have come from a different bed from the *Microceras* and *Metaderoceras spp.* We have seen only one specimen from this cutting that may have been called *Microceras densinodum* and this is presumably from the blue clay judging by its appearance; we identify this as *Metaderoceras* cf. *nodoblongum* (Quenstedt).

The *subplanicosta*-like forms include specimens which can be regarded as typical *Microceras subplanicosta* (Oppel). In addition to these there occurred large numbers of a small smooth ammonite recorded by Mr. Richardson as *Polymorphites polymorphus*, and interpreted by Buckman as an earlier form comparable with *Psiloceras abnorme* (Hauer) in Geyer.[2] (=*Leptonotoceras*, Spath).

The form from Bayliss Hill is pyritized with a thin coating of nacreous material in places, with extremely faint subcostae on the outer whorl. The suture is too complex for *Tubellites tubellum* (Simpson) which it to some extent resembles,[3] and is simpler than that of *Leptonotoceras leptonotum* Spath,[4] but of the same general plan; we refer these forms provisionally to *Leptonotoceras sp.* It may be noted that the horizon in which they are found is higher than that of *Leptonotoceras leptonotum* in Dorset.

A single fragment from this cutting may be regarded as a species of *Deroceras*, perhaps allied to *D. armatum* (J. Sow.). Its horizon is uncertain but in appearance it is different from those recorded from the blue clay, and has a brownish colour; it may therefore represent a lower horizon.

So far as the interpretation of this cutting is concerned the evidence of the Echioceratidae appears to indicate that the horizons represented there are higher than Buckman supposed, and that *Microceras subplanicosta* is above the lower half of the Raricostatum Zone. In the Great Central Railway cuttings near Rugby, Beeby Thompson[5] similarly found finely-ribbed Echioceratids [probably *Plesechioceras*] with *subplanicosta*-like forms and *densinodus*-like forms [? *Crucilobiceras*] below an horizon with *subplanicosta*-like forms, *densinodus*-like forms (several species), *Ammonites muticus* d'Orb. [*Metaderoceras sp.*], *A. spiratissimus* Quenstedt [? *Metechioceras sp.*].

Weston Subedge.—In this cutting clays of approximately the same horizon were exposed. The only ammonites found may be recorded as *Microceras subplanicosta* (Oppel), and *Metechioceras sp.* This is a further indication that these two horizons are not widely separated.

Broadway.—This cutting yields a bigger number of ammonite faunas than those already referred to.

A number of oxynote forms, including some recorded as *Cheltonia acuticostata* (J. Buckman), and *Oxynoticeras oxynotum* (Quenstedt) represent an horizon lower than any seen in Bayliss Hill.

A small pyritized bispinous Derocerate with preservation quite different from that of the other Derocerates found in this cutting may represent a low horizon (? *bispinigerum*). A fragment of a larger Derocerate similar to that

[1] *Op. cit.*, 1920, pp. 69, 70.

[2] Geyer, G., 'Cephalopoden-Fauna von Hierlatz,' *Abhandl. k.-k. geol. Reichsanst.*, Band xii, 1886, pl. ii., figs. 24 and 25.

[3] Reëngured in 'Type Ammonites' vol. v, 1924, Pl. CDXCI.

[4] *Op. cit.* (*Naturalist*, 1925), p. 170.

[5] Thompson, B., 'Geology of the Great Central Railway: Rugby to Catesby,' *Quart. Journ. Geol. Soc.*, vol. lv. 1899, pp. 71-73.

from Bayliss Hill, which was compared with *D. armatum* (J. Sow.), may possibly indicate the *armatum* horizon.

Abundant large fragments of *Metaderoceras* cf. *nodoblongum* (Quenstedt) with a nacreous preservation are probably related to small pyritized forms [*Metaderoceras sp.*].

Microceras subplanicosta is also abundant, with a finely-ribbed compressed species of the same genus.

A single small smooth ammonite, recorded by Mr. Richardson as *Bifericeras tubellum* (Simpson) is similar in suture line to the specimen recorded by us from Bayliss Hill as *Leptonotoceras sp.*, but the whorl is somewhat more compressed and has greater resemblance to that of *L. leptonotum* Spath. *Cymbites globosus* (Oppel) is recorded from this cutting but we have not seen a specimen. The specimen recorded as *C. personatus* is not a species of *Cymbites* and its position is at present uncertain.

The absence of any record of Echiocerates from this cutting is noteworthy in view of the fact that a fauna much below the *nodoblongum-subplanicosta* horizons is present.

Stanton Fields.—Cheltonia accipitris and species of *Oxynoticeras* appear to represent a horizon near the Oxynotum Zone.

The *nodoblongum* and *subplanicosta* horizons are represented by the same forms as those found in the previous cuttings.

A single specimen recorded by Mr. Richardson as *Polymorphites polymorphus* (Quenstedt) is poorly preserved and appears to have suffered erosion. The suture line is too complex for *Tubellites*, and it may be regarded as *Leptonotoceras sp.* From this cutting we have seen one specimen recorded as *Cymbites globosus* (Oppel.) This is comparable with specimens from Folly Lane, Cheltenham, Hunting Butts cutting, and from an excavation at the Gasworks, Gloucester. The *globosus*-like specimens from the cutting are all of a brownish colour. They are not *Cymbites globosus* and have been described as *Paracymbites spp.*[1] The sutures are fairly complex, the outer whorl scaphitoid with strong to faint lateral ornament of peculiar pattern. From this cutting the horizon of the *Cymbites*-like form is uncertain, but as it is recorded from Toddington and from the northern end of the Hunting Butts cutting, where no horizon below '*armatum*' appears to be represented, it is probable that the species is at any rate later than the 'Oxynotum Zone'; also as the *nodobolongum* and higher faunas were not exposed in the latter cutting the horizon is presumably near that of the Echioceratids. Its occurrence at Folly Lane with the same faunas supports this view.

The absence of Echioceratids from this cutting and from Broadway apparently indicates that the sequence is incomplete here.

Toddington.—The numerous brachiopods recorded from the cutting are regarded by Buckman[2] as later in date than the Armatum Zone. Below these were recorded *Cymbites globosus* (Oppel) [? *Paracymbites sp.*, see above], *Deroceras armatum* [a small unituberculate *Deroceras, D.* cf. *miles*]. The specimens recorded as *Polymorphites polymorphus* (Quenstedt) are apparently from two different beds, but they may all be referred to the forms we have called *Leptonotoceras spp.* A number of these specimens are brown in colour and non-pyritic. The others are pyritized with a thin shell of soft nacreous material, similar to the specimens from Bayliss Hill. Similar in preservation to these latter are numerous small Derocerates, striate to finely tuberculate. This form has only been met with in the approach cutting to the southern end of the

[1] Trueman, A. E. and Williams, D. M., *op. cit.*, 1926, p. 247.

[2] *Op. cit.*, 1920, pp. 70-76. The horizon of these brachiopods, which apparently contains no ammonites in this area, is marked thus '?' in Table B (facing p. 16).

Hunting Butts tunnel, and its horizon is uncertain.[1] We have not seen the specimens recorded as *Polymorphites rutilans* (Bean-Simpson).

Bishop's Cleeve.—One ammonite species only, namely, '*Deroceras armatum*' has been recorded from this cutting, and this we have not seen. The associated Rhynchonellids suggest that the cutting does not go below the Armatum Zone, and it is quite possible that the 'Deroceratid' belongs to the *Metaderoceras* horizon.

Evesham Road.—The only ammonite species recorded from this cutting are '*Deroceras armatum* (J. Sowerby),' and '*Echioceras spp.*' The Deroceratids include a form which has been described as *Metaderoceras rubidum* Trueman and Williams.[2] With this is a very small unispinous *Deroceras* with broad, nearly flat venter. All these are preserved apparently in a brownish clay and are similar in appearance to the Echioceratids from this cutting; probably they came from the same bed.

The Echioceratids from this cutting are very characteristic and include *Plesechioceras schlumbergeri* (Reynès), *Leptechioceras subplicatum* Trueman and Williams, and *L. planum* Trueman and Williams. These are believed to occur below the *macdonnelli* horizon, and no specimens more closely allied to *L. macdonnelli* (Portlock) have been seen.[3]

Hunting Butts.—The material from the northern end of the tunnel is quite different in aspect from that of the southern and represents a different horizon. The species are all different and the preservation suggests that the specimens are from a weathered clay, and they are all of the brown colour noted in the Evesham Road specimens. The ammonites include *Metaderoceras fulvum* Trueman and Williams, *Deroceras spp.* (unispinous), the cymbitoid form noted previously, *Leptonotoceras sp.* (very near *L. leptonotum* Spath and different from the specimen at Toddington), and *Plesechioceras* cf. *schlumbergeri* (Reynès). The horizons at the northern end of the tunnel are thus somewhat similar to those exposed at Evesham Road.

At the southern end of the tunnel, the clays yielded '*Bifericeras subplanicosta* (Oppel)' [=*Microceras subplanicosta* (Oppel), and other species], *Deroceras armatum*,' '*Microceras brevispinum.*' and '*Polymorphites rutilans.*' All the fossils are pyritic and were preserved in a blue clay. The specimens referred to as *Polymorphites rutilans* are small unispinous forms, more slender (evolute) than *Am. rutilans* Bean-Simpson in Reynès.[4] These are of different type from any of the fossils seen from the other cuttings. They may provisionally be called *Microceras sp.* The other specimens include *Metaderoceras* cf. *nodoblongum* (Quenstedt), almost identical in character and preservation with those from Bayliss Hill and Broadway; *Crucilobiceras ornatum* Trueman and Williams,[5] *C.* cf. *cheltiense* Spath and *Deroceras sp. juv.* comparable with that noted at Toddington. No specimen comparable with *D. armatum* (J. Sow.) is present in Mr. Richardson's collection from this place.

It is evident that this material represents a different horizon from that seen in the northern cutting and as the specimens have affinities with those

[1] From an excavation at the Gas Works, Cheltenham, Mr. Richardson's collection includes: A cymbitoid-form (comparable with the form noted above); *Crucilobiceras sp. nov.* (comparable with forms noted at Toddington and Hunting Butts S.). The absence of Echioceratids in this excavation, while they are present at several places in the neighbourhood, may be due to the fact that the excavation did not reach those beds; in that case, both the *Deroceras sp. juv.* and the *Paracymbites* must presumably be later in date than the Echioceratids. (See Trueman, A. E. and D. M. Williams, *op. cit.*, 1926, p. 250.)

[2] Trueman and Williams. *op. cit.*, 1926, p. 244.

[3] Trueman and Williams, *op. cit.*, 1925, p. 734.

[4] Reynès, P., Monographie des Ammonites, 1879, pl. 2, figs. 15-19.

[5] Almost identical forms, of similar preservation, have been examined from the excavations at the Gas Works, Cheltenham (footnote 1 above).

from the excavation at the Gas Works, Cheltenham, and from Toddington, the horizon here is probably higher than that of the northern cutting.

Chestnut Farm.—This was a deep cutting in which a large number of horizons were exposed, ranging from the Oxynotum Zone to the horizon with *M. subplanicosta*. The *subplanicosta* horizon is comparable with that at Hunting Butts and appears to include a form near *Crucilobiceras crucilobatum* Buckman. We have seen no specimens resembling *Deroceras armatum* (J. Sow.), but there is a small bispinous *Deroceras* present.[1] *Echioceras* and *Cymbites* are recorded from this cutting but we have not seen the specimens.

The succession arrived at from these studies has been incorporated in Table B (facing p. 16). It will be seen that in general the succession adopted agrees with that proposed by Dr. Spath[2], but that his '*macdonnelli*' horizon is subdivided. The more important faunas from the cuttings would apparently be included by him in the '*macdonnelli*' horizon, but it is apparent from their distribution in the cuttings that several horizons are present. The Echioceratids are related to the *Plesechioceras* and *Leptechioceras planum* faunas more closely than to *L. macdonnelli*. As *Leptechioceras macdonnelli* (Portlock) has not been seen from the area it has been inferred that the horizons represented are pre-*macdonnelli* (*sensu stricto*). In the table it may be noted that the succession *planum-Paracymbites-subplanicosta-nodoblongum* appears to be indicated by the distribution of the faunas. The faunas named as subdivisions of *planum* and *nodoblongum* respectively may not all be separate and in any case there is no evidence as to their succession. Certain of these Echioceratids occur at Radstock, but the species of *Crucilobiceras* and *Deroceras* which are associated with them at Cheltenham are unknown there, a fact which appears to confirm the view that they may be of different dates.

We have found no evidence of the horizons *macdonnelli-aplanatum-exhaeredatum-leckenbyi* in the district. The horizons from *lymense* to *ornatilobatum* are only doubtfully represented, if at all; the species of *Gleviceras* and certain Derocerates may have come from one or more of these lower horizons. The *zieteni-aeneum-raricostatoides* horizons appear to be quite unrepresented.

A comparison of the succession in the Cheltenham district with that at Radstock, Somerset[3] is interesting. In each place a Raricostatum Zone is succeeded by an Armatum Zone, but the faunas in the two localities are almost wholly of different dates. The Armatum Zone of Radstock includes the *exhaeredatum-leckenbyi* horizons and practically no lower Derocerates, while the Raricostatum Zone is mainly *zieteni-raricostatoides* with only a few representatives of the Cheltenham Echioceratid faunas occurring in derived nodules in the Armatum Bed. The relation of these is shown in fig. 2.

[1] Trueman and Williams, *op. cit.*, 1926, pl. xxvii. fig. 10.

[2] *Op. cit.* (*Naturalist*, 1925), p. 169.

[3] Trueman, A. E. and J. W. Tutcher, 'The Liassic Rocks of the Radstock District Somerset),' *Quart. Journ. Geol. Soc.*, vol. lxxxi, 1925, p. 595

Within the Cheltenham-Honeybourne district itself there is evidence of some variations in the succession. Although it is possible that the faunas are not completely represented in the

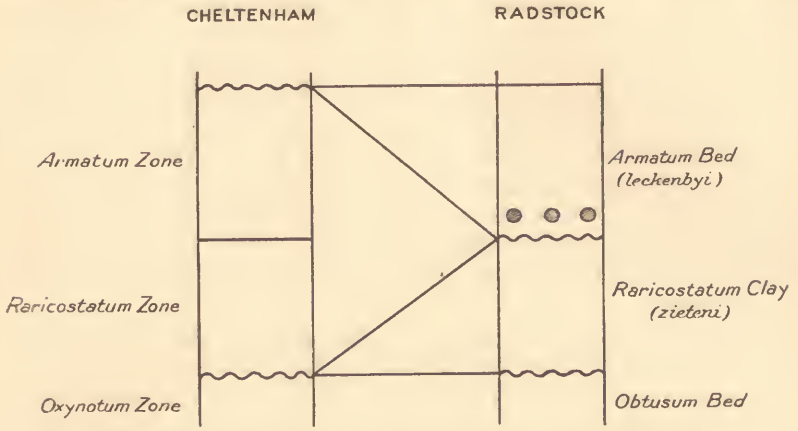

FIG. 2.—*Diagram to illustrate the comparative developments of the Armatum and Raricostatum Zones of Cheltenham and Radstock.*

material preserved by Mr. Richardson, it is noteworthy that the succession is more complete at Bayliss Hill and near Cheltenham than at Broadway and Stanton Fields. In particular the Echioceratid and associated *Deroceras* and *Crucilobiceras* faunas are absent from these cuttings, and it is not unlikely that there is a non-sequence at this horizon. It may be noted that the horizon with *Paracymbites* which appears to be near that of the Echioceratids, is represented in these cuttings, a fact which appears to confirm the view that these Cymbitoids are later than the Echiocerates.

MIDDLE LIAS

The Middle Lias comprises :—

Marlstone—mostly sandy limestone, locally ferruginous: up to	? 36 ft.
Sandy beds—micaceous loams, clays and nodular-limestones: up to	244 ft.

At the present time the only section of the Sandy Beds worthy of mention is that of the lower portion in the pit at the Aston Magna Brick and Terra-Cotta Works by the side of the railway between Blockley and Moreton in Marsh.

The Marlstone is excellently exposed on the northern margin of the district at Chipping Campden (see p. 25) ; is displayed in a quarry above Ashton under Hill ; crops out on the slope of Cleeve Hill above Southam (p. 25) ; and pieces—crowded with fossils—are to be seen in the walls near the last quarry that was ' in work ' on Alderton Hill.

The position of the Middle Lias, however, is readily discernible, The Marlstone or ' Rock-Bed ' gives rise to the flat-topped

Burhill, Buckland, near Broadway; the flat-topped 'shoulders' of the Alderton Hill mass (Pl. 1); the marked southward-sloping (because of the fault along the south side of the hill) 'ledge'—when viewed from the east—of the Oxenton-Hill mass; and the flat-topped spurs that project from the side of Bredon Hill above Ashton under Hill. The Sandy Beds below give rise to a comparatively light soil, frequently dotted with gorse-bushes, and their base is approximately indicated by an effluent seepage of water that is thrown out by the subjacent Lower Lias clays.

The Marlstone is typically an arenaceous limestone, but at Alderton Hill it is more calcareous than is the rule. Locally, it is ferruginous, but insufficiently so in this district to be commercially workable for iron. In the past it has been extensively quarried for road-metal.

In the table is set out the succession of ammonite faunas that has been discovered in the Middle Lias according to S. S. Buckman.[1] The faunas that have been detected in this district are shown by an x in the last column. The evidence for their occurrence has been derived from various records of different degrees of reliability. No doubt additional faunas occur, but owing to the present paucity of sections and to the fact that many of the ammonites that have been collected and preserved in collections have not been re-examined in

Sequence of Ammonite Faunas of the Middle Lias

Oppel's Zones	Geological Survey Zones		Ammonite Faunas	Horizons known in the district
Ammonites spinatus	Paltopleuroceras spinatum	HARPOCERATAN	acutum	x
			athleticum	
			helianthoides ?	?
			paltus	
		DOMERIAN	hawskerense	x
			regulare	
. . . . .	. . . . .		spinatum	x
			argutus	
			gibbosa	x
			margaritatus	x
Ammonites margaritatus	Amaltheus margaritatus		lenticularis	
			laevis	
			Sequenziceras	
			clevelandicus	
			acanthoides	
			boscense	
			fieldingi	

[1] 'Type Ammonites,' vol. v, 1925, pp. 75-76.

the light of present-day knowledge, it is not possible to note here the occurrence of faunas other than those indicated.

Details

In the lane at Ham, Charlton Kings, there is a small exposure of fossiliferous Marlstone, the fossils including *Belemnites paxillosus* Phill., *Rhynchonella tetrahedra* (J. Sow.), *Pinna sp.*, Pectens, and *Modiola sp.* Below are micaceous shales, much indurated in places, containing a few small lamellibranchs. In the grounds of 'The Glenfall,' the picturesque waterfall—depicted in J. Buckman's 'Botanical Guide to the Environs of Cheltenham . . .',—is caused by the presence of the Marlstone.

On the slope of Cleeve Hill above Southam there is an exposure of typical Marlstone. The section is somewhat difficult to find; the best way to get to it is to follow the path which leads up to Nutterswood Cottages (below the quarried face of the hill), but to turn to the left along the west side of Stutfield Wood, when the outcrop of the 'rock-bed' will be observed constituting a little knoll just outside the north-west corner. The fossils that have been obtained here include *Amaltheus margaritatus* Montfort, *Paltopleuroceras sp.*, *Protocardia truncata* (J. de C. Sow.), and *Isocardia liassica* Moore.

Marlstone has been worked at half-a-mile to the south of Gretton, at 'Stanley Hill,' but the quarry is now overgrown.[1] Certain Upper Lias beds were displayed above the 'rock-bed.'

East of Wood Stanway, Stanway, is a noticeable little knoll separated from the main hill-mass by a, relatively speaking, deep valley. This knoll is capped with Marlstone, exposures of which may be observed in the road leading up from the village, and again a few yards to the north of the point where it commences to descend into the afore-mentioned valley.

The flat-topped nature of the hill-spur Burhill, Buckland, is due to the presence of the Marlstone. Formerly the bed was worked, but now all the quarries are abandoned.

The Marlstone is admirably exposed on the outskirts of Chipping Campden in a cutting through which passes the lane to Dover's Hill.[2] The rock displayed is at least 10 ft. thick and contains:—

Paltopleuroceras sp. (*probably* P. pseudocostatum (*Hyatt*)).
Dentalium elongatum *Münster*.
Pseudopecten aequivalvis (*J. Sow.*).
Entolium *aff.* demissum (*Phill.*).
Pteria (Oxytoma) inaequivalvis (*J. Sow.*).
Protocardia truncata (*J. de C. Sow.*).
Gryphaea ? cymbium (young) *Lam.*
Modiola scalprum (*J. Sow.*)
Pleuromya *aff.* costata (*Y. & B.*).
Isocrinus sp.
Ditrupa quinquesulcata (*Münster*).

Marlstone, very fossiliferous, is exposed in the track side near the ruined Baths some 300 yds. S. by W. from the Church, Blockley.

Marlstone, containing specimens of *Terebratula punctata* J. Sowerby, is exposed in quarries west of Maugersbury Grove, near Stow on the Wold, and nine-tenths of a mile E. by N. of Wyck Rissington.

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[1] Smithe, F. and W. C. Lucy, 'Some Remarks on the Geology of . . . Gretton . . .' *Proc. Cotteswold Nat. F.C.*, vol. x, 1891, pp. 209-210.

[2] Richardson, L., 'Excursion to the Vale of Evesham and the North Cotteswolds,' *Proc. Geol. Assoc.*, vol. xviii, pt. 8, 1904, p. 393.

'In a lane leading from Maugersbury to Oddington,' Hull observed a section—which it has not been possible to locate—that may be summarized as follows :—[1]

		Ft.	Ins.
[Upper Lias]	Band of ironstone	0	6
[Middle Lias]	[MARLSTONE] Four beds of calcareous sandstone with partings of clay and shale ...	18	0
	[SANDY BEDS] Sand and sandy shale : about	25	0

The isolated Dixton Hill, with its flat top, stands out like a huge tumulus : the Marlstone that caps it is very ferruginous and contains many belemnites.

On Oxenton Hill there is an indifferent exposure of Marlstone a little to the south-west of Dixton Wood where *Pseudopecten aequivalvis* (J. Sow.) and a few belemnites have been obtained. From the low-lying ground half-way between the villages of Gretton and Alderton the slope of the Marlstone capping the northern spur of Oxenton Hill may be very well seen ; but it should be borne in mind that this somewhat excessive inclination is due to the fault on the south side of the outlier.

The Marlstone at Alderton Hill is very fossiliferous.[2] The locality was once much visited on this account, and for the Upper Lias (see p. 31), but now the quarries are overgrown and the stones in the walls alone demonstrate the cause of its pristine fame. The fossils collected from here include :—

Amaltheus compressus (*Quenst.*)
——— margaritatus *Montfort*
——— nudus (*Quenst.*)
——— spinosus (*Quenst.*)
Paltopleuroceras hawskerense (*Y. & B.*).
——— cf. hawskerense (*Y. & B.*)
——— pseudocostatum (*Hyatt*)
——— pseudospinatum (*Hyatt*)
——— spinatum (*Bruguière*)
Belemnites paxillosus *Phil.*
Actaeonina spp.
Amberleya imbricata (*J. Sow.*)
Ataphrus lineatus (*Moore*)
Cryptaenia expansa (*J. Sow.*)
——— rotelliformis *Dunker*
Pleurotomaria cf. anglica (*J, Sow.*)
Trochus pethertonensis *Moore*
Anomia pellucida *Chap. & Dew.*
Goniomya hybrida (*Münster*)
Gresslya sp.
Gryphaea cymbium *Lam.*
——— gigantea *J. Sow.*
Lima punctata *J. Sow.*
——— succincta (*Schloth.*)
Modiola scalprum *J. Sow.*

[1] 'Geology of Cheltenham' (*Mem. Geol. Surv.*), 1857, pp. 19, 20 ; see also Woodward, H. B., 'Jurassic Rocks of Britain' (*Mem. Geol. Surv.*), vol. iii, 1893, p. 219.

[2] 'Geology of Cheltenham' new ed., 1844, p. 40 ; also Smithe, F. and W. C. Lucy, 'Remarks on the Geology of Alderton, . . .' *Proc. Cotteswold Nat. F.C.*, vol. x, 1891, pp. 202-209.

Pecten aequivalvis *J. Sow.*
——— (Syncyclonema) liasinus *Nyst*
——— (Entolium) substriatus *Roemer*
Pholadomya ambigua *J. Sow.*
Pleuromya costata (*Y. & B.*)
Plicatula spinosa *J. Sow.*
Protocardia truncata (*J. de C. Sow.*)
Pteria cygnipes (*Y. & B.*)
——— inaequivalvis (*J. Sow.*)
Aulacothyris florella (*Deslongchamps*)
——— resupinata (*J. Sow.*)
Lingula sacculus (*Chapuis & Dewalque*)
Rhynchonella acuta (*J. Sow.*)
——— amalthei (*Quenst.*), *and varieties*
——— *cf.* fodinalis *Tate*
——— media (*J. Sow.*)
——— tetrahedra (*J. Sow.*)
Spiriferina rostrata (*Schlotheim*)
Terebratula punctata *J. Sow.*
Zeilleria subnumismalis (*Dav.*)
Hemipedina jardini *Wright.*

—all well preserved.

The Marlstone has been extensively quarried above Ashton under Hill (Bredon Hill). The majority of the quarries are now overgrown. H. B. Woodward gave a section of one of them and observed: 'The lower beds were exposed in a lane-cutting north-west of the village.'[1]

From a quarry 'in work' at Holcomb Nap the writer obtained a specimen of *Amaltheus rotula* (Reinecke).

Upper Lias

The Upper Lias is almost wholly clay: thin limestone bands occur mostly in the basal portion but they are present at Bredon Hill. Locally, in the main hill-mass of the North Cotteswolds, are traces of Cotteswold Sands.

The approximate thickness and top and bottom altitudes of the Upper Lias are as follows at the localities specified:—

	Bredon Hill (above Woollas Hall)	Cleeve Hill	Guiting Power	Batsford	Stow on the Wold —Lower Swell	Iccomb District (little Rissington)
Height above O.D. of top	870	? 930	600	800	600	710
Approximate thickness	270	? 280	? 160	175	83	100
Height above O.D. of base	600	650	? 440	625	517	610

[1] 'Jurassic Rocks of Britain' (*Mem. Geol. Surv.*), vol. iii, 1893, p. 217. See also Smithe, F. and W. C. Lucy, 'Remarks on the Geology of . . .Ashton-under-Hill.' *Proc. Cotteswold Nat. F.C.*, vol. x, 1891, p. 211.

There are no exposures of the Upper Lias in the district at the present time worthy of a visit : only glimpses of the clay—the majority where slipped Inferior Oolite has scarred the slope in which the clay crops out—are available.

On p. 29 is set out the succession of ammonite faunas ascertained —mainly by S. S. Buckman—in the Upper Lias of this country. Those whose presence has been detected in the Upper Lias of the district under consideration are indicated in the last column on p. 29.

On the Old Series Geological Survey Map, Sheet 44, Midford [Cotteswold] Sands are represented as parting the Upper Lias clay from the Inferior Oolite limestones over nearly the whole of the North Cotteswolds. S. S. Buckman remarked :[1] ' What Hull calls and maps as Midford Sands (g^4) in the North Cotteswolds are really the sandy limestone-beds of the *scissi* hemera.'

This is the case with a slight refinement : Hull's Midford Sands of the North Cotteswolds are the Scissum Beds, but they include locally traces of true Cotteswold Sands of unascertained date—may be *variabilis*.

As the boundary line between Lias and Inferior Oolite has not been revised for the New Series Map, Sheet 217, the deposit thereon represented as Cotteswold Sands includes locally Scissum Beds.

The upper portion of the Scissum Beds in the main hill-mass of the North Cotteswolds consists of bedded, sandy, slightly ferruginous, limestones with *Rhynchonella subdecorata, Terebratula* cf. *trilineata* Y. & B., etc. ; but the lower portion, largely of brown (orange) sand. Locally, as near one of the Hinchwick Pools (see p. 71) in the valley of the River Dikler and up one of the tributary valleys (p. 71) are traces of yellowish sands. Their colour and texture at once suggest Cotteswold Sands, and an investigation of their heavy minerals—according to J. G. A. Skerl—prove that first impressions are correct. Care must obviously be exercised in taking samples for examination seeing that these Cotteswold Sands are succeeded by loose Inferior Oolite sands of *scissi* hemera.

An interesting matter concerning the Upper Lias of the district under consideration is this :—In the South Cotteswolds, for example, at Wotton under Edge, the bulk (some 123 ft. out of about 146 ft.) of the Upper Lias is sand (Cotteswold Sands) of *semipoliti-variabilis* hemerae. Northward, as Buckman has demonstrated,[2] the sand is gradually replaced by clay from the bottom upward. At Leckhampton Hill the Scissum Beds rest upon a trace of Cotteswold Sands, in part indurated, of *variabilis* date.[3] Traces of Upper Lias Sands, as already mentioned, are met with locally in the North

[1] *Quart. Journ. Geol. Soc.*, vol. lvii, 1901, p. 151.
[2] *Quart. Journ. Geol. Soc.*, vol. lix, 1903, p. 449.
[3] Richardson L., ' On Two Deep Well-Sinkings at Leckhampton Hill, Cheltenham ' *Geol. Mag.*, 1910, p. 101.

Sequence of Ammonite Faunas of the Upper Lias

Oppel's Zones	Geological Survey Zones		Ammonite Faunas	Horizons known in the district
		DUMORTIERIAN	moorei ...	x
			Catulloceras ...	x
			subsolaris	
			novata	
			levesquei	
			Hammatoceras	
		GRAMMOCERATAN	dispansum	x
Ammonites jurensis	Ammonites jurensis		struckmanni ...	x
			pedicum	
			eseri	
			thouarsense	
			striatulum	
		HAUGIAN	pauper	
			grandis	x
			malagma	
			lilli	?
		HILDOCERATAN	semipolitum ...	x
			subplanatum	
			braunianum ...	x
	Ammonites communis		fibulatum	x
			bifrons	x
			subcarinata	
			pseudovatum	
			A Harpocerate	
			Hildoceratoides	
			crassoides	
Posidonomya bronni	Ammonites serpentinus (falcifer)	HARPOCERATAN	falciferum	x
			Hildaites	
			anguinum	
			Harpoceratoides	
			murleyi	x
			exaratum	
			'Grantham Ammonites'	
			Elegantuliceras	
	Ammonites annulatus		tenuicostatum ...	?

Cotteswolds and it would appear that, roughly speaking, a spread of sand was laid down across the district under consideration from S.W. to N.E. Above the Cotteswold Sands in the South Cotteswolds comes the thin Cephalopoda Bed (at Wotton under Edge 13½ ft. thick) in which are deposits of *moorei*, *Dumortieriae*, *dispansi* and *struckmanni* hemerae. At Cooper's Hill, near Gloucester, there is evidence that deposit of at least one of these hemerae was eroded previous to the deposition of the main mass of the Scissum Beds. No deposits of the four hemerae mentioned have been detected in the North Cotteswolds as yet : if any were laid down above the traces of sands referred to, their nature, thickness, and extent are unknown. But in the vicinity of Bredon Hill (see p. 33) it is known that clays and limestones were deposited during the hemerae *moorei*, *Dumortieriae*, *dispansi*, *struckmanni*, *variabilis*, and *semipoliti*.

In early Inferior Oolite times, in early or pre-*scissi* hemera, flexing of the deposited rocks took place along old lines of weakness : rock was removed along the anticlinal axes and preserved in the synclinal areas. In the vicinty of the Moreton anticlinal axis, near Stow on the Wold (at Duncombe House, p 31), clay not far below the base of the Scissum Beds yielded ammonites indicative of a deposit of *fibulati* hemerae : at Bredon Hill, in the main synclinal area, evidence has been obtained for as late an Upper Lias deposit as one of *moorei* hemera.

Details.

H. B. Woodward recorded that in the railway-cutting at 'Sand[y]well Park,' near Andoversford, were displayed[1] :—

Midford Sands	Rubble of oolite with *Rhynchonella cynocephala*, etc.	
	Micaceous blue and brown sandy loam.	
Upper Lias Clay Zone of Ammonites communis	Blue micaceous clay with cement-nodules, septaria and pyrites, with *Nucula*-bed near top : *Ammonites bifrons*, *A. annulatus*, *A. communis*, *A. holandrei*, *A. lythensis*, *Belemnites elongatus*, and *Arca*	40 or 50 ft.

The 'rubble of oolite with *Rhynchonella cynocephala*, etc.' is doubtless Scissum Beds : the 'micaceous blue and brown sandy loam,' a trace of Cotteswold Sands. A portion of about the same Upper Lias clay was displayed 'between the Dowdeswell turnpike gate and Sandywell Park,' where it was cut through in making the 'new road to London,' and therefrom, in 1831, a number of fossils—including '*Ammonites Walcottii* M.C. t. 106.—*undulatus* Smith Strat. System, p. 114, M.C. t. 254, f. 1 and 2.—*annulatus* M.C. t. 222' —was collected ;[2] but the cutting is now quite overgrown.

From a small exposure at Nutters' Wood, Cleeve Hill, has been obtained a specimen of *Dactylioceras sp.* [Regd. Z. 3835], somewhat like *D. semicelatum* (Simpson), indicative of a deposit of hemera *bifrontis*. Numerous ammonites from the Upper Lias—principally from the Bifrons Zone—of this vicinity are

[1] 'Jurassic Rocks of Britain' (*Mem. Geol. Surv.*), vol. iii, 1893, p. 265.

[2] Murchison, R. I., 'Geology of Cheltenham,' new ed., by H. E. Strickland and J. Buckman, 1844, pp. 34, 35.

to be found in the Noverton gravel pit at Prestbury—above the first ' o ' in Noverton on the map. They include *Dactylioceras* cf. *braunianum* (d'Orb.), *D. holandrei* Wright *non* d'Orb., and *D. raquinianum* (d'Orb.).[1]

From cement-stones dug out from amid clay at the Golf House well near the tram-terminus on Cleeve Hill have been obtained *Hildoceras* cf. *bifrons* (Brug.) [Z. 3849], *H.* aff. *hildense* (*T. B.*) [Z. 3850], and *Pseudolioceras? sp. nov.* (nearest to *P. pumilum* S. Buckman); and from a trial-well sunk in 1910 on Stockwell Common a piece of *Peronoceras bollense* (Zieten) indicative of a deposit of *fibulati* hemera.[2]

Upper Lias clays are well exposed at the spring near Puckham Farm, and, fairly so, at the sheep-wash in Watery Bottom, Postlip.

At ½-mile to the south of Gretton, at ' Stanley Hill,' beds similar to those at Alderton Hall have been displayed. Certain of them could be studied in 1904, but are now hidden. The section noted by C. Moore and the Rev. P. B. Brodie in 1856[3] showed :—

		Ft.	Ins.
Clay and vegetable soil		4	0
Upper Lias (Basement Beds)	Saurian and Fish Bed	1	0
	Blue clay	5	0
	Grey laminated clay	14	0
Middle Lias	Marlstone	3	6

From the Saurian and Fish Bed, T. Wright obtained : ' . . . a large and nearly perfect specimen of *Pachycormus latirostris*, Ag., . . . *Leptolepis concentricus*, Egert., *Tetragonolepis discus*, Egert. Wings and Elytra of Insects . . . '[4]

From clay dug out in making the foundations of Duncombe House, Donnington, were obtained ? *Dactylioceras sp. nov.* [Z. 3828], *D.* ? *sp. nov.* [Z. 3829], and *Porpoceras sp.* [Z. 3830]—all three probably from a deposit of hemera *fibulati*.

' In a lane leading from Maugersbury to Oddington,' Hull noticed a ' band of deep reddish purple ironstone,' 6 inches thick, at the top of the Marlstone, ' filled with good specimens of *Ammonites annulatus* ';[5] but it has not been possible to locate the section.

At Broadwater, ½-mile E.S.E. of Pinnock, clay—containing cement-stones with *Entolium sp.* but not any fossils of zonal value—is exposed at the fine spring.

At Alderton Hill, Alderton, the quarries in the Marlstone, above which was exposed the Upper Lias that obtained such notoriety for the locality, are quite overgrown. There were two quarries : the one, sometimes known as ' Alderton Hill Quarry,' at the southern end of the hill; the other, the ' Dumbleton Quarry,' to the east. A fine collection of fossils was made by Mrs. Hutton (*née* Holland, of Dumbleton Hall), which was described by

[1] Richardson, L., ' Handbook to the Geology of Cheltenham,' 1904, pp. 193, 194.

[2] *Proc. Cotteswold Nat. F.C.*, vol. xix, pt. 3 (1918), p. 198.

[3] Moore, C., ' On the Middle and Upper Lias of the South-west of England,' *Proc. Somersetshire Arch. and Nat. Hist. Soc.*, vol. xiii, 1867, p. 148. See also Smithe, F., and W. C. Lucy, 'Some Remarks on the Geology of Alderton, Gretton, and Ashton-under-Hill,' *Proc. Cotteswold Nat. F.C.*, vol. x, 1891, p. 209; Woodward, H. B., ' Jurassic Rocks of Britain ' (*Mem. Geol. Surv.*), vol. iii, 1893, p. 266; Richardson, L., ' Handbook to the Geology of Cheltenham,' 1904, p. 58.

[4] ' Monogr. Lias Ammonites ' (*Palaeontographical Society*), 1879, p. 117.

[5] ' Geology of Cheltenham ' (*Mem. Geol. Surv.*), 1857, pp. 19, 20. Dr. A. E. Trueman informs me that this ammonite is probably a Dactyloid of a horizon below the Acutum Zone.

T. Wright,[1] and is now housed in the Cheltenham Municipal Museum. The beds have received attention at the hands of many geologists.[2]

Section at Alderton Hill.—After E. A. Walford.

		Ft.	Ins.
[bifrons	1. Soil	2	0
falciferum	2. Rubbly limestone	0	2
murleyi	3. Pale blue grey clay	5	0
	4. Light violet shales interspersed with nodular limestone	3	0
	5. Laminated limestone nodules—Fish Bed containing *Leptolepis concentricus* . . . . *Euomphalus minutus*	0	6
globulina	6. Bluish Paper Shales with nodules ...	0	10
	7. Violet Paper Shales	12	9
	8. Light grey shaly clay	3	0
	9. Dark purple clay [? *Leptaena*-Bed] ...	0	3
	10. Hard band with limestone nodules ...	3	9
	11. Blue clay containing *Am. Holandrei* ...	1	5
	12. Hard marl containing *Rhyn. tetraedra, Am. spinatus, Belemnites,* and *Pentacrinites* ...	1	0
	13. Marlstone Rock Bed	3	4
	(With two other bands not exposed).		

Specimens of *Terebratula globulina* and *Rhynchonella pygmaea* are abundant in the Paper Shales.

S. S. Buckman, whose dating is given alongside the above section (in square brackets) said[3] : ' This is the northernmost point, I think, at which the small *Terebratula* and *Rhynchonella* have been observed ; but their range is wide, as it extends into Normandy. Therefore they are good for dating. It is doubtful whether *Leptaena* has been found at Alderton (Dumbleton). Moore mentioned the *Leptaena* Clays as 15 feet thick there ; but he may have recognised them only by the presence of the *Terebratula* and *Rhynchonella*. H. B. Woodward's citation of *Leptaena* from these clays may have no other basis than Moore's remark. I have collected the *Terebratula* and *Rhynchonella*, but have seen no other brachiopods there, and Mr. Linsdall Richardson mentions the two former, though he does not cite *Leptaena*. Witchell's evidence from Stroud is to the same effect.'[4]

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[1] ' Report on Miss Holland's Collection of Lias Fossils,' *Proc. Cotteswold Nat. F.C.*, vol. iii [1862], pp. 155, 156.

[2] Brodie, P. B., ' Fossil Insects,' 1845, p. 55 ; ' Contributions to the Geology of Gloucestershire . . . ' *Geologist*, vol. i, 1858, p. 230 ; ' Notice on the Discovery of a Dragon-fly and a new species of *Leptolepis* in the Upper Lias near Cheltenham, with a few remarks on that Formation in Gloucestershire,' *Quart. Journ,, Geol. Soc.*, vol. v, 1849, p. 32 ; and *Proc. Cotteswold Nat. F.C.*, vol. ii, 1860, p. 133 ; Murchison, R. I., ' Geology of Cheltenham,' new ed. by H. E. Strickland and J. Buckman, 1844, pp. 35, 36 : Buckman, J., ' On the Occurrence of the Remains of Insects in the Upper Lias of the County of Gloucester,' *Proc. Geol. Soc.*, vol. iv, 1843, p. 211 ; Moore, C., ' On the Middle and Upper Lias of the South-west of England,' *Proc. Somersetshire Arch. and Nat. Hist. Soc.*, vol. xiii, 1867, p. 149 ; Judd, J. W., ' The Geology of Rutland ' (*Mem. Geol. Surv.*), 1875, pp. 58, 59 ; Walford, E. A., ' On Some Upper and Middle Lias Beds in the Neighbourhood of Banbury,' *Proc. Warwickshire Nat. and Arch. F.C.* for 1878 (1879), pp. 11, 12 ; Smithe, F. and W. C. Lucy, ' Some Remarks on the Geology of Alderton . . .,' *Proc. Cotteswold Nat. F.C.*, vol. x, 1891, pp. 202-209; Woodward, H. B., ' Jurassic Rocks of Britain ' (*Mem. Geol. Surv.*), vol. iii, 1893, pp. 266, 267 ; and Richardson, L., ' Handbook to the Geology of Cheltenham,' 1904, pp. 56, 57.

[3] ' Jurassic Chronology : II.', *Quart. Journ. Geol. Soc.*, vol. lxxviii, 1922, p. 391.

[4] Buckman had overlooked C. Upton's evidence for Stroud—' On a Section of the Upper Lias at Stroud,' *Proc. Cotteswold Nat. F.C.*, vol. xv, pt. 3 (1906), pp. 201-207 —Mr. Upton found the *Leptaena*-Bed containing *Cadomella moorei* (Dav.).

The Fish and Insect Bed has yielded :—

Dapedius sp.
Euthynotus, ? sp. nov.[1]
Leptolepis concentricus *Egerton*
Pachycormus (Saurostomus) esocinus (*Agassiz*)
Pholidophorus sp.
Tetragonolepis discus *Egerton*
Dactylioceras annulatum (*J. Sowerby*) [Regd. 3862]. ? *falciferi*
——— cf. gracile (*Simpson*) [3863] *Rhynchonella pygmaea*-Bed.
Geoteuthis agassizi (*Desl.*), and
Teuthopsis brunelii (*Desl.*), *along with detached mandibles, ink-bags, and hooklets.*[2]
? Euomphalus minutus *Schübl* (=Natica pilula *Tate*)
Goniomya tetragona *Wright*
Inoceramus dubius (*J. de C. Sowerby*)
Coleia richardsoni (*H. Woodward*). Holotype [3]
Insect remains, numerous : a collection of these is being investigated.

The Paper Shales (in addition to the brachiopods mentioned) have yielded :—

Numerous specimens of Acrosalenia *cf.* crinifera (*Quenstedt*).
Abundant spines of probably Hemipedina.
Alaria ? sp. nov.
Inoceramus dubius (*J. de C. Sowerby*)

while, at about 2 ft. above the Marlstone, R. F. Tomes[4] obtained :—

Thecocyathus tuberculatus (*Tomes*)
Trochocyathus sp.

A considerable portion of the great outlier of Bredon Hill comes in Sheet 217. The Upper Lias would appear to attain a thickness of 270 feet. There are not any good exposures of it : only local glimpses of it and the usual surface indications—wet ground and slips. It is probably all clay except for occasional limestone nodules and interrupted limestone layers. Nodules may be encountered at various places : at some places they have been collected by farmers to harden field-entrances. In a gravel-pit at Overbury, on the east side of the road between the main part of the village and the Mill, however, are many pieces of Upper Lias limestone which have been derived from the hill. From a study of the fossil contents of these limestone fragments, of others found in a field-gateway on the north slope of the hill, and a specimen of *Catuloceras dumortieri* (Thioll) found in a gravel-pit at Beckford, S. S. Buckman[5] was able to determine that the Upper Lias of the hill contains deposits of the hemerae *moorei, Dumortieriae, dispansi, struckmanni, variabilis*

[1] Woodward, A. S., 'Euthynotus : A Fossil Fish from the Upper Lias of Dumbleton Glos,', *Proc. Cheltenham Nat. Sci. Soc.*, N.S., vol. i, pt. 5, 1911, pp. 322, 323.

[2] Crick, G. C., 'On some Dibranchiate Cephalopoda from the Upper Lias of Gloucestershire,' *Proc. Cotteswold Nat. F.C.*, vol. xx, pt. 3 for 1920 (1921), pp. 249-256.

[3] 'On a New Species of *Eryon* from the Upper Lias, Dumbleton Hill,' *Geol. Mag.*, 1911, pp. 307-311 ; see also Woods, H., 'A Monograph of the Fossil Macrurous Crustacea of England,' pt. ii, 1925, p. 21 (*Pal. Soc.* for 1923).

[4] 'On the Occurrence of Two Species of Madreporaria in the Upper Lias of Gloucestershire,' *Geol. Mag.*, 1886, pp. 107-111.

[5] 'The Toarcian of Bredon Hill, . . . ', *Quart. Journ. Geol. Soc.*, vol. lix, 1903, pp. 445 *et seqq.* Richardson, L., 'Notes on the Geology of Bredon Hill,' *Trans. Woolhope Nat. F.C.*, for 1902, pp. 65, 66 ; 'The Lias of Worcestershire,' *Trans. Worcestershire Nat. C.*, vol. iii, pt. for 1905, pp. 205, 206.

and *semipoliti*.[1] Specimens of *Orbiculoidea*, belonging to three or four species new to this country, are very abundant in many of the limestone fragments. According to Buckman ' The Upper Lias at Bredon Hill, . . . may be said to be, on the fossil evidence obtained, equal not only to the Upper Lias of the Cotteswolds—Wotton under Edge, for example—but also to the overlying Cotteswold Sands and Cephalopod Bed.'[2]

[1] Subsequently *Hildoceras semipolitum* S. Buckman was not considered by Buckman as evidence for *lilli* hemera but for a district hemera—*semipoliti* (*Quart. Journ. Geol. Soc.*, vol. lxxviii, 1922, p. 453 (footnote)).

[2] *Quart. Journ. Geol. Soc.*, vol. lix, 1903, p. 448.

CHAPTER III

INFERIOR OOLITE

The Inferior Oolite in the North Cotteswolds is thicker and comprises more subdivisions than anywhere else in the Cotteswold Hills. As will be gathered from a perusal of the following pages the areas of deposition and the preservation of the subdivisions have been determined by movements along two main lines of earth-weakness, namely, along the Moreton anticlinal and Cleeve Hill synclinal axes. There are apparently two minor flexural axes : a synclinal axis running approximately parallel close alongside the western side of the Moreton axis in the vicinity of Blockley, and apparently—as Hull opined[1]—an anticlinal axis in the vicinity of Winchcomb.

Scissum Beds

The Scissum Beds are co-extensive with the Inferior Oolite tract except (1) possibly in the vicinity of Copse Hill, Upper Slaughter, and (2) in the Iccomb District where Clypeus Grit rests on Upper Lias clay.

On the Cleeve Hill Plateau the Scissum Beds are sandy limestones which are well exposed at the spring near Puckham. In the main hill-mass of the North Cotteswolds the beds comprise (1) an upper portion consisting almost entirely of sandy limestones, and (2) a lower portion consisting mainly of loose brown sands. On the Cleeve Hill Plateau *Rhynchonella cynocephala* (Richard) and *Aulacothyris blakei* Walker, are abundant fossils, and *Hammatoceras* aff. *feurguerollense* Brasil and *Lioceras thompsoni* S. Buckman have been obtained ; while in the main hill-mass fossils are more scarce, but include *Rhynchonella cynocephala* (Richard), *R. subdecorata* Davidson, and *Terebratula trilineata* Young and Bird.

The best exposures of the Scissum Beds are—at the spring near Puckham ; Creddiford Brook (Wood Farm), Guiting Power ; and ½ mile N.E. by E. of Bourton Hill House, Bourton on the Hill parish.

Pea Grit Series

At Cleeve Hill the Pea Grit Series consists of ' Sandy Beds ' resting on massive strata in which beds of Pea Grit occur. At some localities in the Cotteswold Hills appearances are such as to indicate that the massive strata are separable into Pea Grit proper and Lower Limestone and that locally successively higher Pea Grit beds

[1] ' On the Physical Geography and Pleistocene Phaenomena of the Cotteswold Hills,' *Quart. Journ. Geol. Soc.*, vol. xi, 1855, p. 483.

The Inferior Oolite Series: North Cotteswolds

Geological Survey		Approximate Zonal Terms used by Wright	Subdivisions	Hemerae (after S. S. Buckman)	Renevier's Chronographic Subdivisions
Inferior Oolite Series	Upper Stage	Parkinsoni Zone	Clypeus Grit	*schloenbachi-truellei* (late)	Vesulian
			Upper Coral Bed (trace)	*truellei* (early)	
			[*Slight non-sequence*]		
			Upper Trigonia Grit	*garantianae*	
			[*Non-sequence*]		
		Humphriesianum Zone	Phillipsiana and Bourguetia Beds	*sauzei*	Bajocian
			Witchellia Grit	*witchelliae*	
			Notgrove Freestone		
			Gryphite Grit	*shirbuirniae*	
			Buckmani Grit	post-*discitae*	
			Lower Trigonia Grit	*discitae*	
			Tilestone	*concavi*	Aalenian
			Snowshill Clay		
			Harford Sands		
			Naunton Clay		
	Lower Stage	Murchisonae Zone	Upper Freestone	*bradfordensis*	
			Oolite Marl		
			Lower Freestone	*murchisonae*	
			Pea Grit Series (including Lower Limestone)	*Ancolioceras*	
			Scissum Beds	*scissi*	
		Opalinum Zone	Opaliniforme Bed	*opaliniformis*	
			Venustula Bed	*venustulae*	
			Digna Bed	*dignae*	
			Cotteswoldia Bed	*cotteswoldiae*	

overlap one another on the Lower Limestone, but at Cleeve Hill beds of pisolite are encountered amid massive non-pisolitic limestone. For this reason the term ' Pea Grit Series ' is used to embrace the rocks between the Scissum Beds and Lower Freestone in this district.

Where typically developed the Lower Limestone contains abundantly at or near the top specimens of *Variamussium pumilum* (Lamarck) (=*Pecten personatus* Goldfuss et auctt.). Limestones crowded with this little Pecten have been observed at : Stumps Cross, Stanway ; Snowshill ; Cadley Hill, Batsford ; Donnington Hill, Donnington ; (excavation at) Boys' Council School, Stow on the Wold ; and in the bank along the north side of the road between Upper Slaughter and Copse Hill House. East of the Moreton anticline they have been observed at Cornwell.[1]

It appears desirable to refer to these *Variamussium pumilum* Limestones as Lower Limestone.

Pisolitic structure, with the exception of a locality about $\frac{1}{4}$ mile north of Sudeley Park Farm (see p. 54), is absent from the Pea Grit Series equivalent in the main hill-mass ; in this region the Series is generally mainly replaced by the warm brown (' orange ' of commercial circles) ' Yellow Guiting Stone.' The ' Sandy Beds ' facies at the top, however, locally imperfectly reasserts itself, and outside the district to the north, at Ebrington Hill, these ' Sandy Beds ' are probably represented by the sandy beds of The Downs Quarry.

The Pea Grit Series is best seen in the western face of Cleeve Hill ; the ' Yellow Guiting Stone,' in the Jackdaw Quarry, Stanway : the ' Yellow Guiting Stone Quarry,' Temple Guiting ; Piece Quarry, Snowshill ; Bourton on the Hill Quarry, where ill-preserved specimens of *Pseudoglossothyris simplex* (J. Buckman) are to be found ; and Bourtonhill Quarry, near Bourton on the Water.

Lower Freestone

This rock is displayed in a number of quarries. On Cleeve Hill it is worked eastward of the well-known Rolling Bank Quarry, and, in the past, was extensively quarried above Watery Bottom, Postlip. At Temple Guiting it was formerly worked and marketed as ' White Guiting Stone ' ; and at Westington Hill, near Chipping Campden, and about half-way between Whittington and Puckham, it has been ' mined.'

Oolite Marl

The Oolite Marl is well developed, very fossiliferous, and excellently displayed in a number of sections, notably near the

[1] Richardson, L., ' The Inferior Oolite and Contiguous Deposits of the Chipping Norton District, Oxfordshire,' *Proc. Cotteswold Nat. F.C.*, vol. xvii, pt. 2, 1911, p. 202.

Punchbowl Quarry, about the middle of the western face of Cleeve Cloud; in the railway-cutting at Notgrove Station (the finest exposure of the subdivision in the Cotteswold Hills); and in Westington Hill Quarry, near Chipping Campden.

The subdivision is absent from an area in which are located the 'Roadstone Quarry,' near Bourton on the Hill; Sezincote Hill; Stow on the Wold; Copse Hill, Upper Slaughter; and Wagborough Bush Quarry—an area lying along the west side of the Moreton anticline.

Upper Freestone

The Upper Freestone in the North Cotteswolds is a variable deposit as regards lithic structure. At most localities it is ill-defined, comparatively thin, and for the most part 'marly.' Its occurrence is best determined by the finding of *Rhynchonella tatei* Davidson. *Rhynchonella tatei* Beds have been noted:—near Peter's Farm, 720 yds. E. by N. of Broadway Tower; 1½ miles N.N.E. of Cutsdean, near Temple Guiting; Sezincote Hill; and Wagborough Bush Quarry. At the last two localities the beds rest directly, but non-sequentially (the Oolite Marl not being present), on Lower Freestone.

Harford Sands

The Harford Sands constitute a deposit restricted to the North Cotteswolds and derive their name from Harford in the valley of the Windrush between Bourton on the Water and Naunton. They are thickest in the northern portion of the main hill-mass, attenuate to the south-west, and do not extend as far as Charlton Common, near Cheltenham. They are best displayed in 'sand-holes' above Snowshill (8 ft. 4½ ins.+), and on Cleeve Hill (? 6 ft. 8 ins.); but are also seen at Dovedale Farm Quarry, Blockley; the Roadstone Quarry, near Bourton on the Hill (5 ft. 7 ins. +); the 'sand hole' W. of Bourton Hill House (5 ft. 6 ins. +); near Pinnock (3 ft.); Church Farm Quarry, Naunton (about 4 ft. 6 ins.); and in the Aston (4 ft. 9 ins.) and Third (2 ft. 10 ins. +) railway cuttings west of Bourton on the Water. Sand-burrs are an interesting part of the deposit (Pl. III, fig. B).

The formation gives rise to a light sandy soil of comparatively small extent on Cleeve Hill Common (where, however, it is interesting as being the habitat of *Calluna vulgaris*), but of wide extent in the vicinity of Springhill where care has to be taken that its sandy soil is not confused with that to which the Tilestone gives rise.

Locally, as at Church Farm Quarry, Naunton, below the sand deposit is clay, 1 ft. thick, the lower 8 ins. of which contains numerous fragments of oysters. Bed 6 of Hull's record of a section

at Stanway Hill may be its equivalent.[1] At the time the writer considered that the sands and sandy limestones of The Holt Quarry, near Blockley, were Harford Sands instead of Tilestone (as they were subsequently discovered to be) he designated the clay then indistinctly seen below,' Blockley Clay,' and he had in mind to correlate with this Clay that seen at Church Farm Quarry, Naunton. Since, however, the sands and sandy limestone of The Holt Quarry are Tilestone, the clay below is Snowshill Clay. The term ' Naunton Clay ' may be used for the Church Farm Quarry clay.

The Harford Sands are absent from approximately the same area as the Oolite Marl.

Snowshill Clay

Like the Harford Sands the Snowshill Clay (a very tough clay of green, brown, chocolate and black colours) is essentially a North Cotteswold deposit ; but its extent is slightly greater than that of the Harford Sands, its feather-edge reaching to Charlton Common, near Cheltenham, where it rests on Upper Freestone. It is thickest in the vicinity of Blockley : at least 15 ft. was proved—according to the sinkers—in wells at The Holt.[2] Its top portion is seen in trenches for the drainage of The Holt Quarry ; and it is exposed at the ' Roadstone Quarry,' near Bourton on the Hill (5 ft.) ; Sezincote Hill (a trace resting non-sequentially on the *Rhynchonella tatei* Beds of the Upper Freestone) ; Church Farm Quarry, Naunton (1 ft. 4 ins.) ; the quarry near The Fish, Broadway Hill (slipped) ; in an opening by the east side of the Buckle Street some 500 yds. S. by E. of Broadway Tower ; near Pinnock (4 ft. 4 ins. +) ; on Cleeve Hill (1 ft. 6 ins.) ; but is absent from the Aston Farm Cutting and Third Cutting west of Bourton on the Water in which Tilestone rests on Harford Sands.

In the heart of the North Cotteswolds, *e.g.*, in the vicinities of Springhill, Horn's Leazor, and Trafalgar, the Snowshill Clay is an important deposit in connexion with water-supply (see p. 153) ; but locally, owing to faulting, care has to be exercised in order that remnants of Upper Estuarine Clay are not mistaken for it.

The Harford Sands and Snowshill Clay are of *concavi* hemera and remind one of the estuarine beds. The Lower Estuarine Beds of Yorkshire come between deposits of *murchisonae* (Dogger) and *discitae* (Millepore Limestone) hemerae, and are therefore by position of *bradfordensis-concavi* hemerae : hemerae during which the Oolite Marl, Upper Freestone, Naunton Clay, Harford Sands, Snowshill Clay and Tilestone (to be discussed) were deposited in the North Cotteswolds.

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[1] ' The Geology of the Country around Cheltenham ' (*Mem. Geol. Surv.*), 1857, p. 45.

[2] ' Excursion to . . . the North Cotteswolds,' *Proc. Geol Assoc.*, vol. xviii, pt. 8, 1904, p. 396.

Tilestone

The Tilestone owes its name to the fact that S. S. Buckman thought that stone once extensively worked for roofing-tiles at Hyatt's Pits, near Horn's Leazor, was of the same age as ' oolitic fissile stone ' between the Upper Trigonia Grit and Snowshill Clay at Bourton Clump Quarry.[1] The rock formerly worked at Hyatt's and other pits, Buckman's Tilestone of his ' Section xi.—Cross-roads $\frac{3}{4}$ mile south of Hyates Pits, and about $\frac{1}{2}$ mile from Scarborough Barn,'[2] and his Tilestone equivalent ? of his ' Section xii.—Guiting Hill,'[3] however, have been ascertained to be Chipping Norton Limestone ; but the term is retained for the Bourton Clump Quarry rock and its equivalent, which is of *concavi* hemera.

The Tilestone of *concavi* date is best exposed in the Holt Quarry, near Blockley. Here it is separable into an upper sandy limestone portion (with a Conglomerate Bed for the basal stratum), and a lower sand and sandy limestone portion (18 ft. +). The deposit is thicker here—in the Blockley synclinal area—than elsewhere in the area in which it occurs. The extent of this area will be gathered from the citation of the following localities :—Blockley, Campden Hill Farm, Springhill, Bourton on the Hill, and Sezincote Hill ; and the vicinity of Aston Farm, near Bourton on the Water. The ' attenuation ' of the deposit is in the main due to the lower beds having been laid down in the deepest part of a synclinal area and the higher beds overlapping the lower. The upper portion, the sandy limestone, has the widest extent ; but the precise limits of the area of deposition cannot now be outlined owing to probable partial erosion.

The upper portion, containing a multitude of beautifully rolled pebbles of oolite (the result of a pene-contemporaneous erosion) is displayed below Buckmani Grit in the Five Mile Drive Quarry, Blockley parish. The same portion is seen in the ' Roadstone Quarry,' near Bourton on the Hill (4 ft. +, resting on Snowshill Clay) ; Sezincote Hill (6 ft. 6 ins. +, resting on Snowshill Clay and overlaid by Clypeus Grit) ; in the Aston Cutting (2 ft. 2 ins. with Harford Sands below and Lower Trigonia Grit above) ; and in the third cutting west of Bourton on the Water (2 ft. 8 ins., and ditto). It is absent from the vicinities of Stow on the Wold and Wagborough Bush.

In the country around Lapstone Farm (a mile and a half southward from Chipping Campden), and to a less extent near Springhill, the Tilestone gives rise to a very sandy soil : care has to be taken in determining that such soil originates from this subdivision and not from the Harford Sands. Snowshill Clay, of course, separates

[1] ' Bajocian and Contiguous Deposits in the North Cotteswolds : The Main Hill-Mass,' *Quart. Journ. Geol. Soc.*, vol. lvii, 1901, p. 136.
[2] *Idem*, p. 136.
[3] *Idem*, p. 137.

these two subdivisions, but in the hollow toward Springhill sand has been locally washed down from the Tilestone over the outcrop of Snowshill Clay.

Lower Trigonia Grit

At the close of the hemera *concavi* an elevatory movement occurred along the Moreton axis with the result that the Lower Trigonia Grit was not deposited over the greater part of the area in which the Tilestone is preserved.

Lower Trigonia Grit is typically developed on the Cleeve Hill Plateau and over the south-western half of the main hill-mass. It thins from west to east, from Cleeve Hill toward Bourton on the Water, being on the plateau about 7 ft. thick and in the Aston Cutting only 1 ft. 1 in. thick. Its facies in the railway-cutting is that of the feather-edge of a deposit : it is rubbly, whitish, marly, with a level waterworn top and conglomeratic in the lower portion. At many localities in the Cotteswold Hills where it is well developed the basal portion of the Grit is conglomeratic, containing iron-coated and often bored pebbles ; but in the North Cotteswolds, at the sources of water-supplies to Scarborough, Guiting Hill Farm, and Trafalgar, it is thin and remarkably conglomeratic. At the source of supply to Trafalgar the grey, somewhat marly, finely-ironshot limestone matrix contains numerous iron-coated somewhat pitted irregular pebbles of hard grey-brown more coarsely ironshot rock, and of iron-coated somewhat pitted blue-grey-centred argillaceous 'limestone' pebbles. The former have been derived from an earlier portion of the Lower Trigonia Grit : the latter have much the appearance of Upper Lias limestone, but are probably rolled indurated pieces of Snowshill Clay. Roughly speaking, north-eastward of a line connecting (say) Snowshill, Scarborough, and Aston Farm (near Bourton on the Water), the writer has not detected any Lower Trigonia Grit.

Corals (mostly *Chorisastraea gregaria* (M'Coy)) are abundant in the Grit where it is well developed, as on the Cleeve Hill Plateau ; are fairly so at Church Farm Quarry, Naunton ; and are to be met with rarely in the conglomeratic deposit.

Buckmani Grit

The Buckmani Grit—yellowish, sandy limestone, usually very fossiliferous—is well developed and extends north-eastward beyond the limit of the Lower Trigonia Grit. It is seen in the Roadstone Hole on the Cleeve Hill Plateau ; and, in the main hill-mass, in small abandoned quarries—about 585 yds. S.E. by 5°S. of Oldcomb Barn (⅔ mile E. by 7° S. of 'The Fish,' Broadway Hill) ; 180 yds. N.W. of Meadows Barn (⅔ mile S.E. by S. of 'The Fish') ; and (its basal portion) in the Five Mile Drive Quarry ; but the *Terebratula buckmani* sand and clay layer—so readily discernible a constituent

of the subdivision in the Mid Cotteswolds—has not been observed in the main hill-mass. In the Aston Cutting it is only 1 ft. 11 ins. thick, and its facies indicates that the deposit is near the limit of the area of deposition. It is absent from the area in which are situate—the Roadstone Quarry, Bourton on the Hill; Sezincote Hill; Stow on the Wold; Copse Hill, Upper Slaughter; Wagborough Bush; and Bourton Hill, near Bourton on the Water.

Gryphite Grit

The Gryphite Grit is well developed in the North Cotteswolds. It consists of slightly sandy, massive-bedded limestones, and is characterized by a comparative abundance of specimens of *Gryphaea*, and, especially near the top, *Belemnites gingensis* Oppel. Other fossils—with the exception of *Entolium demissum* (Phillips)—are rare: a fact which serves to distinguish it from the underlying Buckmani Grit.

The extent of the Gryphite Grit is slightly greater than that of the Buckmani Grit. It is well displayed, on the Cleeve Hill Plateau in the quarry north of Whittington (about 5 ft.); and, in the main hill-mass, in the Blockley Road Quarry, Blockley parish (8 ft. +). From W. to E., from the Cleeve Hill Plateau toward Bourton on the Water, it attenuates, being in the Third Cutting west of Bourton on the Water 3 ft. thick, and in the Aston Cutting, 8 ins. thick.

Notgrove Freestone

The Notgrove Freestone takes its name from Notgrove, in railway-cuttings near which its correct stratigraphical position was first determined by S. S. Buckman. On the Cleeve Hill Plateau, northward of Whittington, it attains a thickness of 18 feet: in the main hill-mass it is displayed at Oat Hill, Snowshill, to a depth of 25 feet. From W. to E., from the Cleeve Hill Plateau toward Bourton on the Water, it attenuates, being but 7 ins. thick in the Aston Cutting. It is absent from about the same area—apparently a slightly greater area in the vicinity of the Blockley Road Quarry, Blockley parish—as the underlying Gryphite Grit. It is worked in a number of quarries for road-metal, for example, above Snowshill (+14 ft), and at Oat Hill (+ 25 ft.), and is characterized by the little pecten *Variamussium pumilum* (Lamarck) which, locally, occurs in great abundance.

Witchellia Grit

This 'Grit,' in the district under consideration, occurs only on the Cleeve Hill Plateau. It is displayed, owing to faulting, in the Rolling Bank Quarry, Cleeve Hill, where it has yielded specimens of *Witchellia spp.* and *Terebratula wrighti* Davidson—the ammonites

correlating the subdivision with the Upper White Ironshot of Dundry Hill, near Bristol.

Bourguetia and Phillipsiana Beds

These beds are likewise preserved only on the Cleeve Hill Plateau. Over how wide an area they were originally deposited cannot be said: if they were deposited to a certain extent—as is probable—beyond the limits of the Cleeve Hill Plateau all such extra-plateau deposits have been removed by the Bajocian Denudation.

The beds are interesting for the large number of well-preserved fossils that they contain and as being of the same hemera—*sauzei*—as 'The Ironshot' of Dundry Hill, near Bristol. They are best displayed in the Rolling Bank Quarry where their top-bed is exceptionally well bored by annelids and *Lithophagi*.

Deposits of *blagdeni* and *niortensis* hemerae are absent from the district.

Before the Upper Trigonia Grit was laid down an elevatory movement occurred along the Moreton anticlinal axis and the line of maximum depression was along the Cleeve Hill synclinal axis. Erosion, the Bajocian Denudation, ensued. Strata were removed according to their elevation and preserved according to their depression: consequently the highest subdivisions that escaped removal are found on the line of the Cleeve Hill syncline and are the Phillipsiana and Bourguetia Beds. The plane of erosion is marked by the stratum on which the Upper Trigonia Grit rests being waterworn, the surface covered with oysters, and bored. On the Cleeve Hill Plateau the 'Bored Bed' belongs to the Phillipsiana Bourguetia Beds: in the main hill-mass, over the greater part of the district, it belongs to the Notgrove Freestone.

Upper Trigonia Grit

The maximum thickness noted for the Upper Trigonia Grit is 9 ft. It is a very fossiliferous rock and is exposed in a number of quarries, for example, near the Notgrove tumulus and at Oat Hill, Snowshill.

The upper surface of the Upper Trigonia Grit is often found to be covered with oysters and pitted—facts usually indicative of a non-sequence between the surface on which such phenomena are noticeable and the succeeding rock. From this district Dundry Freestone is absent and only very rarely are traces of the Upper Coral Bed (early *truellei* hemera) to be detected. Pebbles of white marly limestone embedded in the basal stratum of the Clypeus Grit in the Rolling Bank Quarry, Cleeve Hill, were probably derived from the destruction of a limited patch of Upper Coral Bed.

Upper Trigonia Grit is absent from a narrow tract in the hill-country immediately west of the Moreton Valley, the Vale of Bourton, the vicinity of Stow on the Wold, and Iccomb District, in which it is overlapped by the Clypeus Grit.

Clypeus Grit

The well-known Clypeus Grit completes the Inferior Oolite subdivisions and has the widest extent of them all. It is magnificently developed in the North Cotteswolds and Iccomb District, attaining a thickness of about 40 ft. 6 ins. in the first cutting west of Notgrove Station. Speaking approximately its lower two-thirds comprises massive limestones and its upper third rubbly limestones packed with fossils—notably *Terebratula globata* auctt. and *Clypeus ploti* Klein. The topmost part of the Clypeus Grit is, locally, as in the Hollow Barn Road Cutting, Eyford, a hard, rubbly, somewhat marly limestone with scattered iron-grains, irregular ferruginous veins, and few fossils. In certain sections difficulty may be experienced in determining whether rubble of rock is Upper Trigonia or Clypeus Grit and where such difficulty occurs it should be remembered that the Upper Trigonia is non-pisolitic, whereas the Clypeus Grit is always pisolitic—even though the pisolites may be few and scattered.

Details of Exposures of the Inferior Oolite

Bredon Hill.—A portion of the large outlier of Bredon Hill comes within the area represented on Sheet 217. The distribution of the Inferior Oolite of the outlier is, in plan, roughly semicircular, and a fault runs along the diameter which has an east and west alignment. By this fault the Inferior Oolite to the north is let down locally against Lower Lias to the south. The Oolite has locally slipped, is much faulted and shattered; but, in general, the strata appear to dip inwards from the margin toward a centre located in Overbury Park. The drainage supports this view: the main outburst of water from the Oolite (from which it is thrown out by the subjacent Upper Lias clay) is in Overbury Park.

The Inferior Oolite of the hill has been studied by Hull,[1] H. B. Holl,[2] H. E. Strickland,[3] H. B. Woodward,[4] and the writer.[5]

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[1] 'The Geology of the Country around Cheltenham' (*Mem. Geol. Surv.*), 1857, pp. 40-42.

[2] 'On the Correlation of the several Subdivisions of the Inferior Oolite in the Middle and South of England,' *Quart. Journ. Geol. Soc.*, vol. xix, 1863, p. 315.

[3] 'Memoirs of H. E. Strickland,' by Sir. Wm. Jardine, 1858, p. 82.

[4] 'Jurassic Rocks of Britain' (*Mem. Geol. Surv.*), vol. iv, 1894, pp. 138, 139.

[5] 'On the Sequence of the Inferior Oolite Deposits at Bredon Hill, Worcestershire,' *Geol. Mag.*, 1902, pp. 513, 514; 'Notes on the Geology of Bredon Hill,' *Trans. Woolhope Nat. F.C.* for 1902, pp. 62-65; 'A Handbook to the Geology of Cheltenham . . .', 1904, pp. 68, 75, 76, 81, 86; 'Bredon Hill: Its Geologic Structure and Water Resources,' *Trans. Worcestershire Nat. Club*, vol. viii, pt. ii for 1924 (1925), pp. 82-88.

The subdivisions of the Inferior Oolite present in the hill are :—

		Ft.	Ins.
? Oolite Marl	Traces		
Lower Freestone	Freestone, whitish, oolitic		
Pea Grit Equivalent	Limestone, compact, yellowish, containing fragments of echinoderms and a few of the characteristic brachiopods	14	0
Lower Limestone	Limestone, massive-bedded, yellowish white, oolitic	34	6
Scissum Beds	Limestones, brown, sandy, ferruginous; a few belemnites, *Rhynchonella cynocephala* (Richard), *Terebratula euides* S. Buckman	33	0

The rocks are locally much disturbed by slipping, much shattered, lime-washed, and the lines of demarcation between the several subdivisions are locally indefinite. Consequently, the thicknesses assigned to the subdivisions are only approximate.

The Scissum Beds are exposed in an old pit about 200 yds. north-west of Kemerton Castle.

The writer has collected from the Pea Grit Equivalent :—*Rhynchonella oolitica* Davidson, R. *subangulata* Davidson, *Terebratula plicata* J. Buckman, *Pseudoglossothyris simplex* (J. Buckman), *Zeilleria circularis* S. S. Buckman, *Diastopora sp.*, *Haploecia straminea* (Phillips), isocrinoid ossicles, and *Pygaster sp.* (? *semisulcatus* (Phillips)).

The Lower Freestone has been extensively quarried above Conderton.

About ½-mile north-east of Conderton there are several disused quarries in the Lower Freestone. At one the writer found (loose) two specimens of *Terebratula fimbria* J. Sow. : they came from either the top portion of the Lower Freestone or a remnant of Oolite Marl.

The North Cotteswolds : The Cleeve Hill Plateau.—The Cleeve Hill Plateau is separated from the main hill-mass of the Mid Cotteswolds to the south by the Chelt Valley and 'Vale of Whittington' and from that of the North Cotteswolds to the east by the Charlton Abbots Valley.

The Inferior Oolite of the plateau has been studied by several geologists[1] : notably by E. B. Wethered,[2] whose attention was directed in particular to the Pea Grit in connexion with his work on the structure of the pisolites ; and by S. S. Buckman,[3] who was mainly concerned with the subdivisions of the Ragstone Beds and their correlation.

[1] Wright T., 'Remarks on the Road Stones of Cleeve Hill,' *Proc. Cotteswold Nat. F.C.* vol, ii, 1859, pp. 184-187 ; 'Additional Notes on Cleeve Hill Section,' *idem*, vol. iv, [1865], pp, 60-74 ; 'Monogr. Lias Ammonites,' 1879, p. 155 (*Pal. Soc.*) : Hull, E., 'The Geology of the Country around Cheltenham' (*Mem. Geol. Surv.*), 1857, p. 45 ; Holl, H. B., 'On the Correlation of the several Subdivisions of the Inferior Oolite . . . ', *Quart. Journ. Geol. Soc.*, vol. xix, 1863, p, 313 ; Woodward, H. B., 'Jurassic Rocks of Britain' (*Mem. Geol. Surv.*), vol. iv, 1894, pp. 133-136 ; Richardson, L., 'A Handbook to the Geology of Cheltenham . . . ', 1904, pp. 67, etc.

[2] 'The Inferior Oolite of the Cotteswold Hills, with Special Reference to its Microscopical Structure,' *Quart. Journ. Geol. Soc.*, vol. xlvii, 1891, p. 556.

[3] 'Deposits of the Bajocian Age in the Northern Cotteswolds : The Cleeve Hill Plateau,' *idem*, vol. liii, 1897, pp. 607-629. A useful map is contained in this paper, p. 628.

Below is set out a generalized account of the Inferior Oolite present in the plateau. The beds are not shown in one connected section and are locally faulted, and a number of quarries have to be visited in order to become acquainted with the complete sequence.

Generalized Section of the Inferior Oolite, Cleeve Hill

		Ft.	In.
Clypeus Grit	Rubbly pisolitic limestone with an admixture of marly matter; usual fossils: seen	12	0
Upper Coral Bed	Traces only locally and pebbles of white limestone remanié in the basement bed of the overlying Clypeus Grit: say	0	2
	[*Non-sequence*: Dundry Freestone absent].		
Upper Trigonia Grit	Ragstone; surface locally with oysters attached thereto: usual fossils ...	9	0
	[*Non-sequence*: deposits of *niortensis* and *blagdeni* hemerae (inclusive) absent]		
Phillipsiana Beds	Limestone, hard, sharp fracture. Well bored by annelids and *Lithophagi*; numerous oysters attached to the surface	0	4
	Similar limestone, but somewhat rounded in places with pockets of 'sand'	0	6
	Similar limestone in three layers with sandy partings; *Terebratula phillipsiana* Walker sparingly	5	0
	Similar limestone; *Terebratula buckmaniana* Walker and *T. phillipsiana* Walker abundant. *Acanthothyris* cf. *paucispina* Buckman and Walker, *Rhynchonella quadriplicata* Dav. *non* Zieten, *Zeilleria anisoclines* S. Buckman	2	3
	Similar massive limestone; *Rhynchonella quadriplicata* Dav. *non.* Zieten, *Terebratula phillipsiana* Walker, *Bourguetia striata* (J. Sowerby)	2	0
Bourguetia Beds	Greyish shelly limestone with brownish patches and infillings; *Bourguetia striata* (J. Sowerby), *Ctenostreon pectiniforme* (Schlotheim)[1]	2	3
	Grey limestone in several beds. Lamellibranchs are numerous and notable for their large size—*Alectryonia* cf. *flabelloides* (Lamarck), '*Modiola explanata* Morris,' etc., *Nautilus* cf. *ornatus* Foord & Crick	7	0

[1] 'A large, umbilicate, much compressed, crassicostate *Stephanoceras* was found by Mr. Upton 2 feet 9 inches below the *Terebratula Buckmaniana*-Bed. Its matrix and position indicate this bed . . .'. S. S. Buckman, *Quart. Journ. Geol. Soc.*, vol. liii, 1897, p. 609 (footnote).

A.—EXPOSURE OF INFERIOR OOLITE ON CLEEVE CLOUD. LOWER FREESTONE AND PEA GRIT SERIES.

B.—EXPOSURE OF INFERIOR OOLITE ON CLEEVE CLOUD. LOWER FREESTONE (INCLUDING OBLIQUELY-BEDDED POLYZOA BEDS) RESTING ON PEA GRIT.

		Ft.	Ins.
Bourguetia Beds	Similar limestone, somewhat bored ...	1	6
	Similar limestone : seen 9 ins. + ? 2 ft.	2	9
Witchellia Grit	Limestone, ironshot ; *Acanthothyris sp.* (small form), *Terebratula wrighti* Davidson, *Zeilleria tenuis* Richardson and Upton[1] *Witchellia sp.* : about ...	4	0
Notgrove Freestone	Limestone, hard, grey, oolitic : no complete exposure, about	15	2[2]
Gryphite Grit	Ragstone ; numerous *Gryphaeae* : no complete exposure : about ...	5	0
Buckmani Grit	Limestone, sandy, grey, shelly : no complete exposure : about ...	?12	0
	Grey clay band with small *Gryphaeae* ...	1	0
	Grey sandy limestone : about ...	4	0

(' Sand Hole ' near the ' Roadstone Hole ')

Lower Trigonia Grit	Limestone, rubbly, slightly ironshot, brownish and bluish-grey ; *Pholadomya fidicula* (J. de C. Sow.), *Pleuromya jurassi* (Brongniart), *Trigonia formosa* Lycett, etc., *Aulacothyris meriani* (Oppel), *Rhynchonella cleevensis* Richardson & Upton, *Terebratula degenerata* Upton, *Zeilleria cleevensis* (Rich. & Upton), *Chorisastraea gregaria* (M'Coy), *Episimilia sp.*, *Kobya sp.* : visible just below the turf on the east side of the opening, 1 ft. ; add for total thickness of the subdivision on the plateau perhaps 6 ft.	7	0
	[*Non-sequence* : Tilestone absent]		
Snowshill Clay	Greyish and purple marl	0	3
	Very stiff, bluish-grey clay	0	6
	Brown clay, enclosing grey stone band 2 ins. thick ; black streaks near base	0	9
Harford Sands	Sandstone, greyish-yellow, calcareous; *Ctenostreon sp.*, *Trigonia sp.*, *Rhynchonella* ? *cleevensis* Rich. & Upton	1	8
	Sand, pale yellow, fine-grained, weathers white (see p. 50) : visible 4 ft. add say 1 ft.	5	0
	[*Non-sequence* : slight]		
Upper Freestone	Oolite : imperfectly exposed but probably of about the same thickness as at Leckhampton Hill where it totals about	25	0
Oolite Marl	White and yellow, calcareous, argillaceous deposit ; many brachiopods —*Zeilleria witchelli*, S. Buckman, *Z. leckenbyi* Walker, etc ; *Mytilus furcatus* Etheridge in Phillips ...	7	0

[1] ' Some Inferior Oolite Brachiopoda,' *Proc. Cotteswold Nat. F.C.*, vol. xviii, pt. 1, 1912, p. 56.

[2] At quarry above Whittington, 18 ft. thick (see p. 51).

		Ft.	Ins.
Lower Freestone	Freestone with at the base the Polyzoa Bed (see p. 50) ; about	60	0
Pea Grit Series	26-21. 'Sandy Beds.' As a rule brownish-yellow sandy rubbly 'marl,' but including locally—particularly in the median portion below the Roman Camp—strata of extremely hard whitish oolitic limestone. Locally the deposit assumes a limestone facies. The basal portion is conglomeratic : up to	20	0
	[*Evidence of erosion*]		
	20. Brecciated deposit being the top-portion of hard 'white' oolitic limestone	3	0
	19. Typical Pea Grit	3	6
	18. Brownish yellow sandy and marly rock. Pisolites. *Rhynchonella oolitica* Davidson : 10 ins. to 2 ft.	0	10
	17. Limestone, massive, 'white,' shelly. The topmost 8 inches contains pisolites	7	6
	16. Limestone, yellow-grey, coarsely oolitic	2	6
	15. Typical Pea Grit	4	6
	14. Grey limestone. Some pisolites ...	3	4
	13. Grey limestone with shell-fragments and a few pisolites	1	6
	12. Hard brown limestone	0	10
	11. Coarse limestone	1	4
	10. Light brown limestone. A few pisolites	1	0
	9. Soft brown limestone	0	7
	8. Brown limestone	0	8
	7. Light brown limestone	0	2
	6. Grey limestone	0	3
	5. Light limestone with yellow patches	0	7
	4. Brown limestone, small pisolites	0	7
	3. Coarse limestone	0	6
	2. Coarse yellow limestone	1	2
	1. Light limestone	1	8
	E. B. Wethered says that 'probably not the lowest beds' are seen, but the Series may be approximately completed by the following rock recorded by H. B. Woodward[1] :—		
	'Shelly and oolitic, more or less pisolitic, limestones in harder and softer beds, *Terebratula, Trigonia*	9	6'

[1] 'Jurassic Rocks . . .' (*Mem. Geol. Surv.*), vol. iv, 1894, p. 134.

		Ft.	Ins.
Scissum Beds	Limestones, sandy, ferruginous, in some places very hard, in others softer with partings of sandy 'marl'; *Rhynchonella cynocephala* (Richard) common, *Terebratula* cf. *trilineata* Y. & B. In yet other places, rubbly and containing a greater variety of fossils: about	8	0

The Scissum Beds are well exposed (1) at the spring near Puckham Farm; (2) in a cutting (through a slipped mass) near White's Barn up Mill Lane (above Knoll Hill Farm), Prestbury; and (3) in the bank near the building alongside Greenway Lane about half-way between the main road to Winchcomb and Nottingham Hill Camp. At (1) and (2) *Rhynchonella cynocephala* (Richard) is abundant, and at (3) the writer obtained specimens of *Hammatoceras* aff. *feurguerollense* Brasil and *Lioceras thompsoni* S. Buckman. He also obtained an example of the former ammonite from an exposure near the Rolling Bank Quarry, Cleeve Hill.

Fossils from the Scissum Beds are to be found loose and in pieces of slipped rock on the Upper Lias clay near the washpool in Watery Bottom above Postlip: they include *Rhynchonella cynocephala* (Richard), *R. subdecorata* Davidson, *Terebratula sp.*, and belemnites.

Both Crane Hill and The Knoll, parts of Oxenton Hill, are capped with Scissum Beds, but the strata are in a most disturbed condition. Crane Hill is an excellent collecting-ground: on a rabbit-warren on the west side of the hill may be picked up *Aulacothyris blakei* (Walker), *Rhynchonella cynocephala* (Richard), *R. subangulata* Davidson, *R. subdecorata* Davidson, *Terebratula euides* S. Buckman, *T. plicata* J. Buckman (*ex* Pea Grit), *T. withingtonensis* S. Buckman, *Gryphaea sp.*, *Montlivaltia sp.*, and *Serpula sp.* The writer found here a specimen of *Hammatoceras* cf. *newtoni* S. Buckman.

The upper portion of the Pea Grit Series is excellently displayed in the western face of Cleeve Hill—that overlooking Thrift and Nutters' Woods: the lower portion is much obscured. Some of the outcrops are natural, and probably most have been produced by masses parting from the parent mass—leaving cliff-like faces behind them—and slipping down the hill-side on the slippery slope of Upper Lias clay. There are a number of examples of such landslides. But in the main the outcrops are artificial: they are the result of extensive quarrying operations in the past, for now no quarries are 'in work.'

The yellow sandy 'marls,' the 'Sandy Beds,' underlie the Polyzoa Bed of the Lower Freestone (see p. 50). Except for a limestone bed near the top they are as a rule of fairly uniform structure. The exception is below the Roman Camp, where, in the median portion in particular, extremely hard 'whitish' oolitic limestone is present. The sandy beds in the first cutting east of Andoversford on the Cheltenham and Banbury Railway are equivalent to these Sandy Beds (p. 74).

The Sandy Beds rest on massive rock. The top portion of the massive rock has been broken up and a layer of breccia formed. Pebbles also occur in the basal portion of the overlying Sandy Beds. Obviously there is a slight non-sequence here.

This 'breccia horizon' can be readily traced below the Sandy Beds along the cliff-like face of the hill, and in the quarry alongside the commencement of Wickfield Lane just outside the northern extremity of the Common.

E. B. Wethered has given a record[1] of the constituent beds of the Pea Grit Series at Cleeve Hill as far down as they were displayed. In the generalized section, p. 48, the numbers 26 to 16 show connexion with his record: the particulars of beds 15 to 1 are transcribed from his record.

Although 56 ft. of Pea Grit Series have been noted below the Polyzoa Bed, this is not the total thickness here, but it would appear that not much above 9 ft. 6 ins. is necessary to complete it.

The Lower Freestone is exposed to a variable extent above the Pea Grit Series along the western face of the hill. Its basal portion embraces the Polyzoa Bed of E. B. Wethered and S. S. Buckman—cavernous (? owing to unequal calcification) limestones, best described as 'rockery stone,' with associated marl and crowded with Polyzoa (*Berenicea exilis* Reuss, *Ceriopora globosa* Michelin, *C. arborescens* Waagen, *Diastopora davidsoni* Haime, *D. foliacea* Lamouroux, *D. mettensis* Haime, *D. wrighti* Haime, *Haploecia sp.*, *Theonoa bowerbanki* Haime, etc.), and isocrinoid ossicles. Echinoid spines, sponges (*Lymnorella inclusa* Hinde, *L. ramosa* Hinde), *Discohelix cotswoldiae* (Lycett), etc., also occur. Of the Polyzoa Bed Wethered said:[2] 'It . . . may perhaps be represented in the Southern [Mid] Cotteswold area by the well-known [Fourth] Coral Bed which occurs at that horizon.'

The Lower Freestone has been worked in a number of quarries on Cleeve Common, but at the present time the only one 'in work' is that a little to the north-east of the Rolling Bank Quarry. In a quarry reached by following Mill Lane from Prestbury to Cleeve Hill until the summit of the hill is attained, there is exposed a fossiliferous and somewhat pisolitic bed in the Lower Freestone that contains *Nerinaeae* and a *Terebratula* of the *T. fimbria* group. Concerning this brachiopod Buckman remarked:[3] '. . . certain peculiar characters distinguish it from the *Terebratula fimbria* of the Oolite Marl—it is, in fact, a biologically earlier fossil, and is the parent of the Oolite Marl shell.'

At about half-way between Whittington and Puckham the Lower Freestone has been 'mined.' The bed forming the roof of the principal 'mine' is interesting: it is of conglomeratic nature, the included pebbles being the product of pene-contemporaneous erosion.

The Oolite Marl is best displayed in a small disused quarry close to the Punchbowl Quarry at the north-end portion of the western face of Cleeve Hill that is called Cleeve Cloud: it contains numerous fossils of which *Zeilleria witchelli* (S. Buckman) is here the most abundant form. The Marl is also seen in a section above Cotehay Farm in the Charlton Abbots Valley.

The Harford Sands are best seen in 'sand-holes' near the Roadstone Hole and toward the north-eastern extremity of the Common. Buckman remarked[4]: "The presence of the sand is often indicated by gorse-bushes. The stone bed [as seen in the 'sand-hole' near the 'Roadstone Hole'] . . . is sometimes partially disintegrated into nodule-shaped masses, which then have the appearance of boulders, and have been the cause of some confusion in the matter of Northern Drift. There is a specimen in the Gloucester Museum,[5] which was obtained from "Roadstone Hole," and preserved as an example of 'that Drift!" (Pl. III., B.)

H. B. Holl[6] grouped the deposits now called Harford Sands with the Upper Freestone, and the overlying 'Brown and blue [Snowshill] clay' with the Lower Trigonia Grit.

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[1] 'The Inferior Oolite of the Cotteswold Hills, with Special Reference to its Microscopical Structure,' *Quart. Journ. Geol. Soc.*, vol. xlvii, 1891, p. 556.

[2] *Op. cit.*, p. 557.

[3] *Quart. Journ. Geol. Soc.*, vol. liii, 1897, p. 617 (footnote 2).

[4] *Idem*, p. 611.

[5] See Lucy, W. C. [Excursion to Cleeve Hill] *Proc. Cotteswold Nat. F.C.*, vol. xi, pp. 7-10 and 2 pls.

[6] *Quart. Journ. Geol. Soc.*, vol. xix, 1863, p. 314.

A.—HOLT QUARRY, 1 MILE W. OF BLOCKLEY. LOWER PART OF THE TILESTONE, LOCALLY SANDY, RESTING ON SNOWSHILL CLAY.

(1)

(2)

(3)

B.—SAND HOLE, CLEEVE HILL, ABOUT 3 MILES W.S.W. OF WINCHCOMB, (1) LOWER TRIGONIA GRIT, (2) SNOWSHILL CLAY AND (3) HARFORD SANDS.

The Snowshill Clay is only thin on the Cleeve Hill Plateau. It is seen between the Harford Sands and Lower Trigonia Grit in the sand-holes mentioned ; it holds up water to form a pond on the Common above the top of Mill Lane ; and throws out springs at Wontley Farm, at a cottage just north of Puckham Farm, and at the gamekeeper's cottage immediately west of Puckham Wood.

The Lower Trigonia Grit is best seen at the sand-holes mentioned ; the ' Roadstone Hole ' ; in the sides of the pond on the Common above the top of Mill Lane ; and in several small excavations at the south-eastern end of the race (training) course. Well rolled and bored (principally by *Lithophagi*) pebbles—to which specimens of *Chorisastraea* and *Serpulae* are often attached—are not of infrequent occurrence in the basal portion of the Grit. In this basal portion corals (on Cleeve Hill chiefly specimens of *Chorisastraea gregaria* (M'Coy)) are abundant and constitute what has been called the ' Second Coral Bed,' in descending order, of the Inferior Oolite of the Cotteswold Hills. Fossils, particularly Lamellibranchs, are abundant and well preserved.

Of the Gryphite Grit Buckman observed[1] that ' the greater part . . . , and its connexion with the Notgrove Freestone, may be clearly seen in the quarry above, and to the east of, the Rolling Bank, near the Ordnance-datum 972 on the 6-inch map. Similar observations may be made at the Whittington Quarry.'

' *Whittington* : *Ragstone Quarry and Fields* ; *about* 600 *yds. nearly north of the Church* [*S. S. Buckman*][2]

		Ft.	Ins.
Upper Trigonia Grit	1. Shelly ragstone. [*Non-sequence* : deposits of *niortensis-blagdeni* hemerae (inclusive) absent]		
Phillipsiana and Bourguetia Beds	2. Greyish and yellowish-green sandstone, with *Terebratula Buckmaniana*. Several pieces of this matrix are much bored by annelids. Also stones of a more or less ironshot matrix : about ...	23	0
Witchellia Beds	3. Shelly ironshot with *Acanthothyris* . . . about	3	0
Notgrove Freestone	4. A whitish oolitic stone. A *Sonninia* of the *fissilobata-ovalis* type was found at the bottom. This deposit is fully exposed in the quarry ...	18	0
Gryphite Grit	5. A shelly ragstone with *Gryphaeae* and small smooth pectens, exposed for about ... ... (The quarry has been worked about 6 ft. deeper and the spoil heaps show a sandstone with *Terebratula uptoni*. The horizon of this fossil at Charlton Common is 7 ft. below the top of the Gryphite Grit [and denotes Buckmani Grit].	3	0

Note.—The details of beds 1-3 were obtained by breaking the stones in the soil of the field to the northward, measuring the rise of the ground, and allowing for the dip.'

[1] *Quart. Journ. Geol. Soc.*, vol. liii, 1897, p. 612.
[2] *Idem*, p. 608.

The connexion of the Notgrove Freestone with the Witchellia Grit, and of this latter subdivision with the Phillipsiana and Bourguetia Beds may be seen in the Rolling Bank Quarry.

The Phillipsiana and Bourguetia Beds are not to be found anywhere else in the Cotteswold Hills outside the Cleeve Hill Plateau where they are best seen in the Rolling Bank Quarry. Just over ½-mile north-west by west of Cotehay Farm a small quarry displays the top-bed of the Phillipsiana Beds—according to Buckman the Bourguetia Beds[1]—much bored, and containing a few examples of *Terebratula buckmaniana* Walker.[2]

In the Rolling Bank Quarry the top stratum is exceptionally well bored by annelids and *Lithophagi*, and has oysters attached to its surface. Upper Trigonia Grit (9 ft. thick) succeeds, so there is a non-sequence: deposits of *blagdeni* and *niortensis* hemerae are absent. The surface of the Upper Trigonia Grit is waterworn and also has oysters attached to it, and has resting on it Clypeus Grit. There is another non-sequence: Dundry Freestone is absent, and the Upper Coral Bed is represented merely by traces locally and pebbles of white limestone remanié in the basement layer of the Clypeus Grit.

The Clypeus Grit is best displayed in this Rolling Bank Quarry in which about 12 ft. of it are seen. Buckman considered that some red clay seen in a portion of the quarry-face is a relic of Fullers' Earth.[3]

No traces of either Chipping Norton Limestone or Upper Estuarine Clay have been detected on the Cleeve Hill Plateau. The Limestone has probably been overlapped by the 'Fullers' Earth.' This 'Fullers' Earth' may include a basement layer of Upper Estuarine Clay; on the other hand this Upper Estuarine Clay may have been overlapped by the grey Fullers' Earth such as forms the bulk of the Fullers' Earth seen in the Roundhill railway-cutting (see p. 112).

Langley Hill.—This hill is an outlier of the Cleeve Hill Plateau

Langley Hill Quarry, near Winchcomb[4]

		Ft.	Ins.
Lower Freestone	Limestone, yellowish-white, oolitic, very conspicuously obliquely-laminated; fragments of *Isocrinus*: seen	33	0
Pea Grit Equivalent	Limestone, soft, oolitic; *Pseudoglossothyris simplex* (J. Buckman), isocrinoid ossicles	6	0
	Limestone, brownish, rubbly-looking; full of Polyzoa—*Apsendesia cristata* Lamouroux, *Diastopora michelini* (Blainville) etc.; *Rhynchonella subangulata* Davidson, *Terebratula sp.*, *Pseudoglossothyris simplex* (J. Buckman)	2	2
	Limestone, brownish	1	4
	Soft brown marly matter	0	4
Lower Limestone	Limestones, massive-bedded; spines of echinoids, etc. seen	3	4
	[Gap]		
Scissum Beds	Limestones, brown, sandy, massive in places; *Rhynchonella subdecorata* Davidson, *Terebratula euides* S. Buckman.		

[1] *Quart. Journ. Geol. Soc.*, vol. lvii, 1901, p. 131.

[2] 'Richardson, L., 'A Handbook to the Geology of Cheltenham . . .', 1904, p. 124.

[3] *Quart. Journ. Geol. Soc.*, vol. liii, 1897, p. 618.

[4] Richardson, L., 'A Handbook to the Geology of Cheltenham . . .', 1904, p. 86.

The Scissum Beds were exposed in the side of the path leading down from the summit of Stanley Mount—the name of the western portion of the hill of which the eastern portion is called Langley Hill—down to Stanley Pontlarge.

The Scissum Beds must be unusually thin here, for in one of his sections ' of the whole series of the sands from the base of the Inferior Oolite,' Hull gave, below the Inferior Oolite[1] :—

	Ft.	Ins.
' Calcareous sandstone bored by lithodomus, with belemnites	0	6
Lower calcareous sandstone	1	6
Yellow sand, becoming light blue and clayey downwards ...	4	0 '

In addition to the Scissum Beds the Pea Grit Equivalent appears to be thin. These facts are interesting in connexion with the minor Winchcomb anticlinal axis (see p. 8).

The North Cotteswolds : The Main Hill-Mass.—The Inferior Oolite of the North Cotteswolds was studied for the representation of its distribution on the Geological Survey Map (Old Series), Sheet 44, by E. Hull, who gave some particulars of the formation in the explanatory memoir published in 1857.[2]

No further investigation of note was carried out until close upon half a century later, when, in 1901, appeared S. S. Buckman's communication ' Bajocian and Contiguous Deposits in the North Cotteswolds : The Main Hill-Mass.'[3] The occurrence of Chipping Norton Limestone in the district, however, was not detected, and in the vicinity of the Buckle Street for what are now known to be Chipping Norton Limestone and Upper Estuarine Clay a *concavi* date was suggested.

In 1903 the writer described ' . . . a Section of Great Oolite Beds at Condicote . . . '.[4] He appreciated that the beds displayed did not belong to the Inferior Oolite, and, as the fossils had a Great Oolite facies he referred the beds to the Great Oolite Series. He was unaware at that time of the occurrence of Chipping Norton Limestone in this neighbourhood ; but now he would refer the beds to that subdivision.

In 1904 a party of the Geologists' Association of London visited the North Cotteswolds and an account of the geology, so far as it was then understood, was given in the report of the excursion.[5]

The Cotteswold Naturalists' Field Club has visited the district on several occasions, and references to the reports of the excursions will be found in the appropriate places in following pages.

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[1] ' The Geology of the Country around Cheltenham ' (*Mem. Geol. Surv.*), 1857, p. 29.

[2] ' The Geology of the Country around Cheltenham ' (*Mem. Geol. Surv.*), 1857, pp. 29, 30, 36, 37-39, 45-51.

[3] *Quart. Journ. Geol. Soc.*, vol. lvii, 1901, pp. 126-154.

[4] *Geol. Mag.*, 1903, p. 404.

[5] *Proc. Geol. Assoc.*, vol. xviii, 1904, pp. 391-408.

Local Details

At ½-mile S.E. by S. of Sevenhampton Church, in an old quarry—now nothing more than a track-side exposure—are seen traces of typical Lower Trigonia, Buckmani and Gryphite Grits, and Notgrove Freestone.

In the bank alongside the track-way that climbs the hill to Tughill Barn, and immediately west of Hawling Lodge, are seen brown sandy Scissum Beds, then a fault, Snowshill Clay (traces), Lower Trigonia, Buckmani and Gryphite Grits, Notgrove Freestone (with the top-layer well bored and oysters adherent to its surface), and, succeeding non-sequentially, the Upper Trigonia Grit.

At Roel Gate there was in 1904[1] a disused quarry in which, below Lower Trigonia Grit, was displayed Snowshill Clay.

About ¾-mile north of Roel Gate, on the east side of the road and east of Lime Hill Wood, is a quarry ' in work ' (1926).

Lime Hill Wood Quarry

In Notgrove Freestone in which a wide fissure has had let down into it :—

Upper Estuarine Clay. Clay, dark tough,

[*Non-sequence* : Chipping Norton Limestone absent] between Notgrove Freestone and infilling of

Clypeus Grit. Typical.

Pea Grit Equivalent, very similar to that of Bredon Hill, was formerly extensively worked at Brockhampton, and therefrom have been obtained *Pseudoglossothyris simplex* (J. Buckman), *Terebratula plicata* J. Buckman, and *Rhynchonella* cf. *subangulata* Davidson.

There is a large disused quarry in Spoonley Wood in a slipped mass. It displays :—Lower Freestone (much bored by annelids), Pea Grit Equivalent, etc. (a brown rock of considerable thickness), and ? Scissum Beds (brownish sandy limestone with belemnites).

In the north side of the little valley about ¼-mile N. of Sudeley Park Farm is a small quarry in which is exposed a bed of typical pisolite, and it may be that it was here that T. Wright obtained several echinoids recorded in his Monograph as from ' Sudel[e]y Hill.'

The quarry—' Dirty Quarry '—in which S. S. Buckman noted his Sudeley Hill section is now mostly overgrown. The following is Buckman's record[2] :—

Sudeley Hill

		Ft.	Ins.
Notgrove Freestone	Fragments in soil.		
Gryphite Grit	Yellowish marl and stone ; *Gryphaea*	1	6
	Shelly ragstone, with numerous *Gryphaeae* ; and with *Belemnites gingensis* near the top	2	0
Buckmani Grit	Yellowish, sandy stone with *Trigoniae*, *Terebratula uptoni* 3 ft. down ; *T. buckmani*, single, 4½ ft. down. The top of this series is a somewhat hard projecting bed. Visible	8	0
	Add perhaps	2	0

[1] Richardson, L.' A Handbook to the Geology of Cheltenham . . . ', 1904, p. 100.

[2] ' Bajocian and Contiguous Deposits in the North Cotteswolds : The Main Hill-Mass,' *Quart. Journ. Geol. Soc.*, vol. lvii, 1901, p. 131.

		Ft.	Ins.
Lower Trigonia Grit	Hard, brown-speckled, somewhat sandy stone. *Ostrea*; smooth *Pecten*; very large *Cucullaea*. Lower 2½ ft. visible at a waggon-loading ledge. Possible thickness	7	0
	[The part above the 2½ ft. is hidden by rubble over the face of the quarry.]		

Notes.—Some 20 ft. lower down the hill is an exposure of what look like Harford Sands, near the bench-mark 920, on the right-hand side of the road to Winchcomb. There is an undoubted exposure of these sands in a rabbit-burrow, in the copse under the steep brow of the hill to the left. This is at about the same level. The sandstone is crowded with lamellibranchs. A measurement makes it 45 ft. below the Notgrove Freestone. About another 25 ft. lower is an exposure of Oolite Marl with *Terebratula fimbria*.

At ¾-mile east of Sudeley Lodge, in the angle made by the Hawling and Lower Guiting (Guiting Power) roads, is Straits Quarry—Buckman's ' Farmcott Wood ' Quarry[1]—still ' in work.'

	' Farmcott Wood ' Quarry	Ft.	Ins.
Upper Trigonia Grit	Ragstone; usual fossils: seen ...	6	0
	[*Non-sequence*: deposits of *niortensis-witchelliae* (late) hemerae (inclusive) absent].		
Notgrove Freestone	Limestone, whitish, very oolitic; top portion bored, level surface with oysters adhering	6	9
	Limestone, similar, but very noticeably obliquely laminated: seen ...	8	0

At more than ¼-mile to the south-east of ' Farmcott Wood ' Quarry an old shallow working on the east side of the road is in typical Clypeus Grit.

At ¼-mile to the S.S.E. is a quarry—' Hawling track Quarry '[2]—' in work,' in which the ' Bored Bed ' (the top stratum of the Notgrove Freestone) is very prominent. The section shows 6 ft. of Notgrove Freestone with 2 ft. 3 ins. of Upper Trigonia Grit above. The ' Bored Bed ' occurs at or near the surface over a considerable area west of Roel, and masses of it are extensively used for ' toppers ' to the field-walk.[3]

A quarry 1¼-miles E.S.E. of the last, on the north side of the road, shows :—

	Quarry ⅜-mile N.N.E. of Roel Farm	Ft.	Ins.
Upper Trigonia Grit	Ragstone. (Seen at the top of the western end of the quarry.)		
	[*Non-sequence*: Deposits of *niortensis-witchelliae* hemerae (inclusive) absent]		
Notgrove Freestone	Limestone, oolitic, top-bed—seen towards the top at the western end of the quarry—bored. In some places the limestone is massive, but, on the whole, broken up, and, locally, weathering so as to present a—what is exceptional for this subdivision—' nodular ' appearance: seen ...	13	0

[1] *Quart. Journ. Geol. Soc.*, vol. lvii, 1901, p. 130.

[2] Richardson, L., ' A Handbook to the Geology of Cheltenham . . . , 1904, p. 120.

[3] *Cf.* Hull, ' The Geology of the Country around Cheltenham ' (*Mem. Geol. Surv.*), 1857, p. 46.

A little lower down, in the field close to the track to Wood Farm, is an old quarry in which there are traces of white marl and limestone-rubble (Oolite Marl), with *Terebratula fimbria* J. Sowerby and *Rhynchonella lycetti* Davidson, resting on Lower Freestone.

In a cutting through which the old British track-way known as 'The White Way' passes at about ½-mile west of Castlett Farm, Temple Guiting, Scissum Beds—grey-brown sandy limestones containing *Variamussium pumilum* (Lamarck), etc.—are displayed. Of this section S. S. Buckman remarked[1]: 'At Creddiford Brook are some 18 ft. of a brown sandy stone, and in about the middle of the section a bed yielding somewhat plentifully, but not often perfect, specimens of *Rhynchonella subdecorata*. It yields also lamellibranchiata, *Nerinaea*, etc.; so that it is quite a fossiliferous exposure.'

At 'Pinnock Farm,' 'somewhat between Farmcott Wood and Stanway Hill,' S. S. Buckman noticed a section of Harford Sands, and ? Upper Freestone equivalent.[2] At ½-mile N.W. of Pinnock is the following section:—

Pinnock Quarry

		Ft.	Ins.
Snowshill Clay	Clay: seen	3	0
	Cream-coloured clayey marl	1	4
Harford Sands	Sandstone, hard	1	10
	Limestone, marly, oolitic, ironshot ...	1	2
Upper Freestone	Limestone, cream-coloured; *Terebratula* cf. *submaxillata* Morris, *Modiola sp.*	0	9
	Marl and limestone, white and cream-coloured	0	6
	Limestone, cream-coloured: seen ...	2	0

Snowshill Clay throws out the spring on the hill-side W.S.W. of Ford that is piped to supply the hamlet.

H. B. Woodward has given the following account of the beds seen in the vast Jackdaw Quarry,[3] in which the 'Yellow Stone' is now only occasionally worked in a small portion.

Jackdaw Quarry, Stanway

		Ft.	Ins.
[Lower Freestone, passing down into Pea Grit Equivalent or 'Yellow Stone']	Well-bedded oolite, much jointed and false-bedded in places	25	0
	White oolite	3	0
	Brown oolite (best freestone) ...	6	0
	Yellow oolite	10	0

Coscombe Quarry, S.E. of Stumps Cross, between Coscombe and Ford, displays about 32 ft. of 'Yellow Stone.' (Pl. IV., B.)

On Stanway Hill, adjoining the west side of the Old Campden Road, at ½-mile west of Taddington, is a quarry (Hornhill Quarry)—now planted with trees, where only the Buckmani and Lower Trigonia Grits are exposed—the section in which has been described by S. S. Buckman[4]:—

Stanway Hill

		Ft.	Ins.
'T. *Buckmani* Grit. vii.	1. Stone with marl; *Gryphaea* and *Ostrea*	5	0

[1] *Quart. Journ. Geol. Soc.*, vol. lvii, 1901, p. 150.
[2] *Quart. Journ. Geol. Soc.*, vol. lvii, 1901, p. 133.
[3] 'The Jurassic Rocks of Britain' (*Mem. Geol. Surv.*), vol. iv, 1894, p. 137.
[4] 'Bajocian and Contiguous Deposits in the North Cotteswolds: The Main Hill-Mass,' *Quart. Journ. Geol. Soc.*, vol. lvii, 1901, p. 132.

		Ft.	Ins.
Lower *Trigonia* Grit. viii.	1. Stone with *Hyperlioceras* (?) in section	0	8
	2. Marl with *Hyperlioceras* (B) ...	1	0
	3. Rubbly stone	0	9
	4. Marl with stone	2	0
	5. Whitish stone	3	0
	6. Slightly ironshot stone	0	6
	[*Non-sequence*]		
Snowshill Clay. ix.	1. Dark clay band (1), *Belemnites* ...	0	3
	2. Dark ironshot marl	0	4
	3. Brown ironshot stone	0	5
	4. Dark ironshot marl, '*Graphoceras*' *sp.*, *Belemnites*, *Ostrea Marshii* (A)	0	6
	5. Brown ironshot limestone	1	6
	6. Yellow sandy clay	0	3
	7. Very ironshot marly stone, coarse grains of limonite	0	9
	8. Finely laminated bluish-yellow clay	1	5

NOTES.—A lump of Oolite-Marl matrix was found at the entrance to the quarry. The Snowshill Clay deposits are interesting and fossiliferous. It is unfortunate that their further development downward is hidden by much fallen debris, for I have not yet discovered any exposure of these rocks with similar characters. The bed ix. 7 is a remarkable kind of pisolitic ironstone, different from any other bed in the Cotteswolds.

The '*Graphoceras*' *sp.* is interesting, bearing out the suggestion made in former papers as to the date of the Snowshill Clay—that it was of *concavi* hemera. It is not a true *Graphoceras*, not having a proper V-script radial line, and it is a species different from any one obtained from Dorset or Somerset. It is, however, a Graphoceratoid, and has a concave umbilicus; moreover, it is akin to certain species found in the *concavi* hemera of Dorset. As ammonites are very scarce in the Cotteswold Inferior Oolite, the find is very satisfactory.'

Of the lithic character of the Lower Trigonia Grit Buckman noted that it is entirely altered from that at Sudeley Hill, etc.

Hull gave the following record of the 'Ragstone' at Stanway Hill[1]:—

	Stanway Hill	Ft.	Ins.
[Buckmani and Lower Trigonia Grits]	'1. Thin-bedded, brown calcareous sandstone, alternating with marly beds, with *Modiola plicata* *Ostrea Marshii*, and *Trigonia* (casts)	7	6
[Harford Sands]	2. Yellow calcareous sandstone ...	2	0
	3. Variegated sandy shales	4	6
	4. Light brown sandstone	1	0
	5. Variegated sandy shales and clay	8	0
[? Naunton Clay]	6. Yellow, brown, and black shale, with a bed of small oysters ...	2	0
[? U. Freestone]	7. Hard limestone with blue centre ...	3	0'

Hull appears to have obtained evidence here for a clay or shale-deposit between the Harford Sands and Upper Freestone comparable with the Naunton Clay of Church Farm Quarry, Naunton, and of the Ford well-sinking (see p. 39).

[1] 'Geology of the Country around Cheltenham' (*Mem. Geol. Surv.*), 1857, p. 45.

'Near the top of Stanway Hill, on the old road from Tewkesbury to Moreton in Marsh,' S. S. Buckman noted[1] :—

'*T. Buckmani* Grit	In the quarry.
	Ragstone with *Belemnites insculptus* and *B. gingensis* [and *T. buckmani* Dav.] Unseen—to road.
	By the side of the road.
Snowshill Clay	Brown ironshot stone like A in the other quarry.
	Bluish clay.
	A coarsely oolitic, somewhat ironshot freestone.
Tilestone equivalent (?)	A fine-grained freestone.
Harford Sands	Indications of sand.'

Harford Sands, Snowshill Clay, etc., are well exposed in an old quarry about 1¼-miles N.E. by N. of Notgrove Station near Church Farm (*olim* Naunton Inn), Naunton.

Church Farm, Naunton

		Ft.	Ins.
Lower Trigonia Grit	Limestone, rubbly ironshot; *Isastraea* cf. *flemingi* (Milne Edwards and Haime) *Montlivaltia* cf. *smithi* Edw. and Haime, *Montlivaltia* sp. and other fossils: up to	2	0
	[*Non-sequence*: Tilestone absent]		
Snowshill Clay	Clay, brown and blackish, locally sandy	1	4
Harford Sands	Sandstone, calcareous	1	6
	Sand, brownish-yellow, argillaceous; imperfectly exposed, about ...	3	0
Naunton Clay	Clay, tough, blue and brown	0	4
	Clay, yellow, 'marly,'[2] with numerous oysters of the *Ostrea sowerbyi*-type...	0	8
Upper Freestone	Limestone, hard, sparsely-oolitic, conchoidal fracture: seen	3	0

This section is interesting because it reveals: (1) the presence of a thin clay deposit between the Harford Sands and Upper Freestone; (2) the absence of the Tilestone; and (3) the occurrence of typical Lower Trigonia Grit.

The top portion of the Upper Trigonia Grit, traces of the Upper Coral Bed (containing *Holectypus depressus* (Leske)) and *Pedina salteri* de Loriol (*olim P. rotata* Wright *non* Agassiz), and a considerable thickness of Clypeus Grit, are exposed in a quarry by the high road some 300 yds. S. of the Church, Naunton.

Typical Clypeus Grit, full of specimens of *Clypeus ploti* Klein, is seen at Aylworth.

Three miles E. by S. of the Church Farm Quarry, Naunton, is a quarry—with a lime-kiln—that may be called 'Wagborough Bush Quarry.' It shows Clypeus Grit resting on the upper portion of the Upper Freestone (that characterized by *Rhynchonella tatei* Davidson) and this upon Lower Freestone.[3]

[1] *Quart. Journ. Geol. Soc.*, vol. lvii, 1901, p. 32.

[2] A sample has been 'washed,' but the residue consisted only of fragments of oysters and a few ooliths.

[3] *Proc. Geol. Assoc.*, vol. xviii, 1904, p. 404.

Wagborough Bush Quarry, Upper Slaughter

		Ft.	Ins.
Clypeus Grit	Typical : about	5	6
	Limestone, slightly oolitic, shelly, iron-stained, passing up into typical Clypeus Grit. *Rhynchonella tatei* Dav. (derived) at base	0	9
	[*Non-sequence* : deposits of *truellei* (early)—*concavi* hemerae (inclusive) absent]		
Upper Freestone	Rubbly yellowish deposit ; *Ostreae* in places on upper surface ; *Rhynchonella* cf. *subobsoleta* Dav., *R. tatei* Dav., *Terebratula fimbria* J. Sow. (5 to 12 ins.)	0	8
	Yellowish-white oolite ; *Terebratula fimbria* J. Sow. (rare), *Rhynchonella tatei* Dav. : average	1	3
	A greenish and yellowish rubbly deposit clayey in places ; full of *Rhynchonella tatei* Dav., *R.* cf. *subobsoleta* Dav., *Terebratula fimbria* J. Sow. (0 to 6 ins.)	0	3
	[*Non-sequence* : lower portion of Upper Freestone and Oolite Marl absent]		
Lower Freestone	Hard stratum of limestone ; makes a conspicuous feature	0	8
	Massive-bedded limestones ; the higher beds are the more oolitic. *Terebratula fimbria* J. Sow. 4 ft. 1 in. below the top-bed of the Lower Freestone : seen about	8	0

About ½-mile to the east, at the turning to Lower Slaughter from the Upper Slaughter road, is a quarry in a slipped mass of rock. In the extreme southern corner of the quarry, Clypeus Grit, crowded with specimens of *Terebratula globata* auctt., is seen resting—without the intervention of any Upper Freestone—on Lower Freestone. To the left, shortly after entering the quarry, are seen brownish sands with pieces of brown sandy limestone (Scissum Beds) and, may be, Cotteswold Sands.

Ascending the hill on the road from Upper Slaughter to Lower Swell one may observe, between the former village and the entrance to Copse Hill House, in the bank on the left hand side, traces of Cotteswold Sands and Lower Limestones but no definite evidence for Scissum Beds.

Opposite to the entrance to Copse Hill House is the Town Quarry in which Clypeus Grit is seen resting on basal Lower Freestone.[1]

Town Quarry, near Copse Hill House, Upper Slaughter

		Ft.	Ins.
Clypeus Grit	Typical : seen	4	9
	Hard bed full of specimens of *Pleuromya spp.*	0	6
	[*Non-sequence* : deposits of *truellei* (early)—*murchisonae* (late) hemerae (inclusive) absent]		

[1] Richardson, L., ' Excursion to Bourton-on-the-Water . . . ', *Proc. Cotteswold Nat. F.C.*, vol. xvi, pt. 1, 1907, p. 24.

		Ft.	Ins.
Lower Freestone	Limestone, hard, oolitic, top-bed bored and has oysters adhering to its surface, passing down into somewhat massive, yellowish, iron-stained oolitic limestones ... ... (In the deepest excavations)	3	10
Pea Grit Series Equivalent	Very ferruginous, ' cavernous ' and (?) bored beds, full of ossicles of *Isocrinus* and fragments of echinoid-radioles, and below are—Limestones, hard, brownish, *Terebratula sp.* indet.: seen	8	6

The top-portion of the Clypeus Grit, below Chipping Norton Limestone, is seen in Hollow Barn road-cutting on the Stow road about ½-mile N.E. by E. of where the River Eye is crossed by that road.

Returning to the valley of the Windrush in the vicinity of the Guitings evidence for Oolite Marl, Upper Freestone (including the portion containing *Rhynchonella tatei* Dav.), Naunton Clay (full of oysters of an *Ostrea-sowerbyi*-type), Harford Sands, and Lower Trigonia Grit, is to be obtained in and in the vicinity of an old quarry in the hill-side east of Kineton—between Guiting Power and Temple Guiting.

At ¾-mile north-east of Temple Guiting are the ' Guiting Stone ' Quarries : that in the corner of the field, in the ' Yellow Guiting Stone ' ; that in the wood, in the ' White Guiting Stone.'

On the south side of the Stow road, about 200 yds. before its crossing by the Buckle Street and at about 886 ft. above Ordnance Datum, is a hollow in which may be observed rubble of Clypeus Grit. At about 300 yds. to the east, also to the south of the road and at between about 906 and 918 ft., is Bevan's Quarry in the Chipping Norton Limestone.

A little more than ¾-mile eastward of Bevan's Quarry is a by-road to Lower Barn and Trafalgar Farm from the Stow road. At the junction of the by-road and main-road is a quarry in Chipping Norton Limestone : between this quarry and Lower Barn, in a bank alongside the by-road, an exposure of typical Clypeus Grit.

For the distribution of the Clypeus Grit in the ' Condicote District ' the reader is referred to Dr. F. B. A. Welch's map which is reproduced on p. 116. At ⅔-mile east-north-eastward from Ford, near Temple Guiting, a well was sunk in a field in 1925. The writer did not go down the well, but particulars of the subdivisions penetrated were obtained by an examination of the rock that had been dug out and approximate thicknesses by letting down a bobbed string.

Well-sinking near Ford

		Ft.	Ins.
Notgrove Freestone	Typical (also seen in an old quarry 300 yds. to the east) : seen ...	5	6
Gryphite Grit Buckmani Grit	Limestone, pale-yellow, sandy : *Belemnites sp.*, *Cucullaea sp.*, *Modiola furcata* Goldfuss *Pholadomya ovulum* Agassiz	7	6
Lower Trigonia Grit	Limestone, rubbly, marly, ironshot, highly conglomeratic (? about 1 ft.)		
Snowshill Clay	Black shale (? in the lowest part) packed with oysters of an *Ostrea-sowerbyi*-type	2	0
Harford Sands.			

Just over ½-mile N. by E. of the well and ½-mile W. by N. of Cutsdean Hill Barn is an old quarry in which is seen the basal portion of the Oolite Marl—with *Terebratula fimbria* J. Sow., *T. submaxillata* Morris, and *Rhynchonella subobsoleta* Dav.—and the top-portion of the Lower Freestone.

At the corner of the field south-west of Fordhill Farm is a small disused quarry in which Upper Trigonia Grit is seen resting on a well-bored surface of Notgrove Freestone; while in the same field, but to the north-eastward, is a quarry 'in work' displaying 2 ft. 9 ins. of Upper Trigonia Grit resting on 6 ft. of Notgrove Freestone.

Rubble of Clypeus Grit occurs on the portions of the three fields adjacent to the east side of the Buckle Street that are situate to the south of the turning to Scarborough.

Specimens of *Terebratula fimbria* J. Sow., are to be picked up on the portion of the ploughed field adjacent to the track from the Buckle Street to Oldborough—the barn N.W. by N. of Fordhill Farm.

About 150 yds. from the crossing of the Buckle Street and Horn's Leazor-Stanway road, close to the north side in Heaver Plantation, is a quarry in Chipping Norton Limestone (see p. 90). On the upper portion of the field to the west, just below the 900-ft. contour-line, and say 10 ft. below the altitude of the bottom of Heaver Plantation Quarry, is much field-rubble of typical Clypeus Grit with *Clypeus ploti* Klein, *Terebratula globata* auctt., and *Pholadomya murchisoni* (J. de C. Sowerby), etc.

Clypeus Grit, Upper Trigonia Grit, and Notgrove Freestone are exposed in an old quarry some 150 yds. E. by S. of Trafalgar. Snowshill Clay throws out the springs that feed the cement bottomed impounding pond down in the valley to the eastward.

Highly conglomeratic Lower Trigonia Grit is seen above Snowshill Clay, which throws out the water, at the springs that supply Scarborough and Cutsdean Lodge—some 220 yds. S. by W. of Scarborough; and Trafalgar and Guiting Hill Farm—at about ½-mile S. of Scarborough, just within the plantation.

In the side of Oat Hill to the S. of Snowshill is a quarry.[1]

	Oat Hill Quarry, Snowshill	Ft.	Ins.
Clypeus Grit	Rubbly rock—typical Clypeus Grit; crowded with *Pleuromya spp*; *Entolium demissum* (Phill.), *Limatula gibbosa*: seen		
	Limestone, rubbly, whitish, with few fossils	4	0
	[*Non-sequence*: Upper Coral Bed and Dundry Freestone absent]		
Upper Trigonia Grit	Ragstone, slightly ironshot; usual fossils. The upper surface of this bed is bored in places and covered with oysters	2	5
	Rubbly, marly deposit, distinctly ironshot; *Terebratula globata* auctt. ...	0	8
	[*Non-sequence*: deposits of *nior-tensis-witchelliae* (late) hemerae (inclusive) absent]		
Notgrove Freestone	Limestone, hard, with whitish ooliths. Top level and covered with oysters; top-bed bored: seen	25	0

[1] Presumably this is the quarry noticed by S. S. Buckman in *Quart. Journ. Geol. Soc.*, vol. lvii, 1901, p. 133. See also Richardson, L., *Proc. Geol. Assoc.*, vol. xviii, pt. 8, 1904, p. 392.

A little less than 1 mile E.N.E. of Snowshill is a quarry ' in work ' for roadstone in which Notgrove Freestone, packed with specimens of *Variamussium pumilum* (Lamarck), is exposed to a depth of about 14 ft. At ⅔-mile to the E. of Snowshill is another quarry ' in work ' in similar rock (depth of face 12 ft.), in which the characteristic little pecten is abundant, and a grypheate oyster not uncommon.

In 1904[1] very fossiliferous Oolite Marl was exposed in a low bank alongside the road thirteen-sixteenths of a mile E.S.E. of Snowshill and therefrom have been collected :—*Pseudoglossothyris curvifrons* (Oppel), *P. nana* S. Buckman, *Terebratula fimbria* J. Sow. (very rare), *T. submaxillata* auctt., *Rhynchonella lycetti* Dav., *R.* aff. *granulata* Upton, *R. subobsoleta* Dav. (somewhat rare), *Zeilleria leckenbyi* (Walker), *Z. witchelli* S. Buckman, *Ctenostreon sp.*, *Cucullaea sp.*, *Lucina wrighti* Oppel, *Modiola sp.*, *Pholadomya sp.*, *Alectryonia* cf. *flabelloides* (Lamarck), *Pleurotomaria sp.*, etc. A little to the south comes a fault, for in the valley bottom by the concrete-bottomed pond is clay (? Upper Estuarine Clay), and in the old quarry south of the pond Chipping Norton Limestone (Tilestone form).

The ' sand hole ' or quarry ⅔-mile E. by 15°N. of Snowshill Church, which was described by S. S. Buckman in 1901[2] and visited by the Geologists' Association in 1904,[3] has long been abandoned, and is much overgrown. It showed Harford Sands consisting of :—

		Ft.	Ins.
Harford Sands	Sandy loam : seen	2	6
	A massive bed of sandstone with numerous *Nerinaea* of various species ; *Astarte sp.*, *Modiola sp.*, *Ostrea sp.*, *Terebratula sp.*, *Serpula* aff. *socialis*	2	2
	Fine white quartzose sand, with flakes of mica and some calcareous portions : seen	3	6

The Sands, however, are now worked further to the west—in the western corner of the field, where the following section is to be seen :

		Ft.	Ins.
Harford Sands	Sandstone	2	8
	Sand, brown	1	9
	Sand, weathering white	1	5
	Clay layer	0	0½
	Sand weathering white with local ' doggers '	2	6

Close by is an old working in freestone crowded with specimens of *Terebratula fimbria* J. Sowerby.

The lower portion of the Lower Freestone and the top portion of the ' Yellow Stone ' are seen in an old quarry between the last exposure and the village ; the ' Yellow Stone ' is worked at Piece Quarry close to the road ; and brown ferruginous limestone (Lower Limestone)—with a layer full of specimens of *Variamussium pumilum* (Lamarck)—is seen in a low bank at the cross-roads at the eastern extremity of Snowshill village (see p. 37).

Rubble of typical Clypeus Grit, containing *Terebratula globata* auctt., is seen on the field about 250 yds. down the valley from the junction of the Snowshill road and Buckle Street in the direction of Springhill. Further down the valley a small spring—running into a shallow trough—is thrown out

[1] Richardson, L., *Proc. Geol. Assoc.*, vol. xviii, pt. 8, 1904, p. 393.

[2] *Quart. Journ. Geol. Surv.*, vol. lvii, 1901, p. 133.

[3] *Proc. Geol. Assoc.*, vol. xviii, pt. 8, 1904, p. 392. Also described by H. B. Woodward, ' Jurassic Rocks of Britain ' (*Mem. Geol. Surv.*), vol. iv, 1894, p. 140.

by the Snowshill Clay. Still further down, but just above the 800-ft. contour-line of the west side of the valley, another spring is thrown out by the Clay : it is collected in a feed-tank from which it gravitates to a ram at the barn which forces the water up to Snowshill Hill.

From the valley side north of the barn referred to above another spring is thrown out by the Snowshill Clay. Below are traces of sandy soil (Harford Sands), while, at a lower level, is an old quarry :

Hare Park Quarry, Springhill

		Ft.	Ins.
Oolite Marl	Limestone, whitish, passing down into more broken up but otherwise similar rock ; *Terebratula fimbria* J. Sow. abundant, *Pseudomelania sp.* ...	10	0
Lower Freestone	Limestone, fairly massive : seen ...	15	0

The basal portion of the Lower Freestone and the ' Yellow Stone ' are seen in an old quarry in The Dingle about 700 yds. E. by S. of Springhill, and again in a quarry ¾-mile to the northward of the house where some of the rock is burnt for lime.

Between the lodge ½-mile north of Springhill and Seven Wells, and between Seven Wells and Sally Beds (to the northward of Heath Farm), there are ample surface-indications of the presence of Snowshill Clay. Buckman remarked that at Seven Wells there is ' perhaps as much as 20 feet of it.'[1] It has been dug for puddle by the east side of the Buckle Street some 500 yds. S. by E. of Broadway Tower, where it is exposed to a depth of 3 ft. Sandy soil and gorse at a higher level to the east suggest the presence of the succeeding ' Tilestone Sands.'

The section in the large quarry south-west of ' The Fish ' on Broadway Hill—of which particulars have also been given by H. B. Woodward[2]—is as follows :—

Quarry near the Fish Inn, Broadway

		Ft.	Ins.
Lower Freestone (Lower portion)	Rubble and shattered beds : seen ...	10	0
	White Stone. Oolite, false-bedded in thin beds	9	0
Pea Grit Equivalent or ' Yellow Stone '	Red Bed. Massive oolite	4	0
	Yellow Bed. Massive oolite ...	5	6

The Clypeus Grit and the Upper Trigonia Grit have been let down by faulting in the centre of the section presented in the south face of the quarry, and are underlaid by a blackish and extremely tough clay (Snowshill Clay).

By the side of the Buckle Street some 350 yds. slightly E. of S. of ' The Fish ' is an old quarry in which is seen rubble of Notgrove Freestone (with *Variamussium pumilium* (Lamarck)) and Gryphite Grit. Probably this was the Quarry, near the ' Fish Inn,' in which H. B. Woodward noticed limestones with ' *Pecten personatus*.'[3]

A little less than ½-mile south-east of ' The Fish,' on the south-west side of the Stow on the Wold road, is a quarry showing, imperfectly :—

? Gryphite Grit	Limestones, rubbly, brown, sandy ; *Belemnites gingensis* Oppel.
Buckmani Grit	Limestones, brown, sandy ; *Belemnites gingensis* Oppel, *Ctenostreon pectiniforme* (Schlotheim), *Entolium demissum* (Phill.), *Acanthothyris globosa* S. Buckman.

[1] *Quart. Journ. Geol. Soc.*, vol. lvii, 1901, p. 134.

[2] ' Jurassic Rocks of Britain ' (*Mem. Geol. Surv.*), vol. iv, 1894, p. 140.

[3] *Idem*, p. 140.

Lower Trigonia Grit	? Absent.
? Tilestone	Limestones, sandy imperfectly exposed.
? Snowshill Clay	A small spring was rising through a fissure in ? the bottom bed of ? Tilestone on April 6th, 1925.

About 250 yds. to the south is a small old quarry in which is exposed sandy Buckmani Grit limestone containing *Belemnites gingensis* Oppel, *Pseudomelania* sp. (internal cast), *Gervillia acuta* J. de C. Sow, *Gresslya abducta* (Phillips), *Entolium demissum* (Phillips) (small form—abundant), and *Trigonia sp.*

Wet ground, in April, 1925, at a slightly lower level to the south probably indicated the presence of Snowshill Clay (which holds up the water in the well at Meadow's Barn) ; while at 220 yds. to the S.W. by W. of the small old quarry, Oolite Marl (with *Terebratula fimbria* J. Sow. and *Rhynchonella granulata* Upton) has been turned out by moles. At ¼-mile S.W. by S. of Meadows' Barn, rubble on the field is replete with specimens of *Terebratula fimbria* J. Sow. The old quarry near the western boundary wall of the same field is in fine-textured, greyish limestone, with *Lucina*—the lithic characters and the fossil suggesting the Tilestone above the Conglomerate Bed as seen in The Holt Quarry, Blockley (p. 67).

The ' Yellow Stone,' with numerous ferruginous ramifications (' iron bars ') in the lower portion, is seen in an old quarry 220 yds. W. by S. of Oldcomb Barn ; rubble of Oolite Marl with *Terebratula fimbria* J. Sow., and *Pseudoglossothyris curvifrons* (Oppel), on the field at 260 yds. to the S.E. by S. ; and Buckmani Grit, with *Ctenostreon pectiniforme* (Schlotheim), and *Chlamys sp.*, at about 585 yds. to the S.E. by 5°S.

In the large quarry on Westington Hill is the finest section of Oolite Marl and Lower Freestone in the North Cotteswolds. It has been described by H. B. Woodward,[1] S. S. Buckman,[2] and the writer.[3]

Westington Hill Quarry, near Chipping Campden

		Ft.	Ins.
Harford Sands	' Yellowish sand, in pockets ' (seen by H. B. Woodward).		
Upper Freestone	Limestones, oolitic, thin bedded ...	2	6
	Stone, pale, marly	2	0
	Clay, yellow	2	9
	Limestone, hard, grey, oolitic ...	1	10
Oolite Marl	Marl, pale, indurated, and marly stone with scattered ooliths ; *Cidaris* (plates), *Natica ' leckhamtonensis '* Lycett, *Pleurotomaria sp.*, *Alectryonia* cf. *flabelloides* (Lamarck) *Lucina wrighti* Oppel, *Ostrea sp.*, *Pholadomya sp.*, *Rhynchonella auriculifera* Rich. & Upton, *R. lycetti* Dav., *R.* of a *subangulata* type, *R. subobsoleta* Dav., *Terebratula fimbria* J. Sow., *T. submaxillata* Morris, *T. whitakeri* Walker, *Zeilleria leckenbyi* (Walker), and a multitude of immature forms of *Rhynchonella* and *Zeilleria*. *Isocrinus*-ossicles	9	6

[1] ' Jurassic Rocks of Britain ' (*Mem. Geol. Surv.*), vol. iv, 1894, p. 141.

[2] *Quart. Journ. Geol. Soc.*, vol. lvii, 1901, p. 150. Buckman's record is reversed owing to an error in transcription from his note book.

[3] *Proc. Geol. Assoc.*, vol. xviii, pt. 8, 1904, pp. 393-395. In the present section the commencement of the Oolite Marl is put at 6 ft. 7 ins. lower down.

		Ft.	Ins.
Lower Freestone	Oolite, massive bedded used for planking, covering drains, culverts, and road-mending: 5 ft. 6 ins. to ...	7	0
	Rubbly ferruginous sandy and calcareous deposit, called 'Ironstone': 1 ft. 6 ins. to 2 ft.	1	4
	Oolitic freestones:—		
	WHITE POST, used for building: 6 ft. to	7	0
	Yellow freestone, false-bedded in places; with bored-bed in the middle of the stone; used for carving' (H. B. Woodward): 5 ft. to	7	6
	Freestone: seen	3	7
	'Ragstone and sandy and ferruginous beds proved by boring to a depth of 44 ft.' (H. B. Woodward)		

In a field, and close to the road, some 250 yds. to the S.W by W., is a small pond. It is maintained by a small spring thrown out by the Snowshill Clay from the 'Tilestone Sands,' of which there is ample evidence in mole-heaps.

'At Stanley's quarry, north-east of Northwick Hill Farm, near Blockley, about 36 ft. of oolite [Lower Freestone] has been exposed. The top layers are much lime-washed, and these beds are too hard, as a rule, to be worked as freestone; they are burnt for lime, and used for building walls and for road-metal. The lower layers, which are more false-bedded, are quarried for freestone.'[1]

Lower Freestone is seen in three old quarries in the plantation above Furze Bank to the west of Northwick Hill, and the 'Yellow Stone' in a quarry towards the western extremity of Norcomb Wood.

There are abundant indications of Snowshill Clay at, and to the west of, Northwick Hill; in the southern and western extremities of the field south of Lapstone Farm; and at the western extremity of the field to the west of the farm. In the field to the south of Lapstone Farm, running eastwards from the cottages and at a higher level than the Snowshill Clay, is ample evidence of 'Tilestone Sands.'

At ¼-mile W. by S. of Lapstone Farm is an old quarry—S. S. Buckman's 'Section viii.—Near Campden Hill Farm,'[2] Buckman's record is as follows:

'Section viii.—*Near Campden Hill Farm.* (South of Old Campden Road.)

		Ft.
Upper Trigonia Grit	I. Somewhat rubbly, yellowish, crystalline stone, with *Rhynchonella subtetrahedra, Rh. hampenensis, Zeilleria waltoni, Terebratula globata, Acanthothyris spinosa* ... ... (Parting conspicuous. Top planed off, pitted, covered with oysters, but not bored. An inconstant band of stone above, with oysters, is bored.)	2¾
Notgrove Freestone	V. Whitish crystalline stone (*Trigonia signata*). Roadstone	7'

[1] Woodward, H. B. 'Jurassic Rocks of Britain' (*Mem. Geol. Surv.*), vol. iv, 1894, p. 141.

[2] *Quart. Journ. Geol. Soc.*, vol. lvii, 1901, p. 134. The name Campden Hill Farm is now used for what was formerly Rectory Farm, and what was formerly Campden Hill Farm is now called Lapstone Farm.

Notgrove Freestone was pointed out in this quarry to a party of the Geologists' Association of London in 1904.[1] Since 1904 the quarry has been worked farther to the south-eastward, but the quarry is now abandoned. In the last-worked portion is the following section :—

Quarry near Lapstone (olim *Campden Hill*) *Farm*

		Ft.	Ins.
Upper Trigonia Grit	Ragstone ; usual fossils : seen, up to ...	4	0
	Occasional slabs of *Isastraea* : 0 to ...	0	4
	[*Non-sequence* : deposits of *niortensis-witchelliae* hemerae (inclusive) absent]		
Gryphite Grit	Limestone, more or less rubbly, with occasional partings of shale and stone passing down into more massive rubbly beds. *Belemnites gingensis* Oppel not uncommon along a line at 1 ft. to 1 ft. 6 ins. below upper limit. Up to	8	0

Thus at this point no evidence was obtained for Notgrove Freestone.

At about ⅔-mile southward of the quarry ' Near Campden Hill Farm,' in the angle made by the Five Mile Drive and the road to Blockley, is a quarry ' in work.'

Blockley Road Quarry

		Ft.	Ins.
	Brown clay subsoil.		
Clypeus Grit (traces) and Upper Trigonia Grit	Traces of rubble of typical Clypeus Grit at the top ; rubble and yellowish marl ; Upper Trigonia Grit ragstone. The beds are much mixed up ; *Alectryonia* cf. *flabelloides* (Lamarck), *Gresslya sp.*, *Pleuromya goldfussi* (Lycett), *Entolium demissum* (Phill.), oysters, *Acanthothyris spinosa* (Schloth.), *Rhynchonella hampenensis* S. Buckman, etc., *Terebratula globata* auctt. (very rare), *Acrosalenia spinosa* Agassiz, *Clypeus* aff. *hugi* Agassiz : seen	4	0
	[*Non-sequence* : deposits of *niortensis-witchelliae* hemerae (inclusive) absent]		
Gryphite Grit	Limestones, somewhat irregularly-bedded, grey but blue-hearted weathering brownish, somewhat sandy, with irregular partings of brown shaly marl. *Modiola sowerbyana* d'Orbigny (found loose), *Entolium demissum* (Phill.), large pectens, *Trigonia* ? *costata* Sowerby, oysters in body of rock : seen ...	8	0

This section is of interest for the excellent display of the Gryphite Grit.

Lower beds are seen in a quarry some 150 yds. to the S.E of The Double Lodges on the Springhill estate alongside the Five Mile Drive.[2]

[1] *Proc. Geol. Assoc.*, vol. xviii, 1904, p. 395.

[2] See Richardson, L., *Proc. Geol. Assoc.*, vol. xviii, 1904, p. 396.

Five Mile Drive Quarry

		Ft.	Ins.
Buckmani Grit	*At the south-east end of the quarry*—Rubble of grey limestone and some yellow sandy 'marl'; *Alectryonia* cf. *flabelloides* (Lamarck), *Gervillia acuta* J. de C. Sowerby, *Camptonectes sp.*, *Entolium demissum* (Phill.) small and numerous, *Pleuromya sp.*, *Trigonia formosa* Lycett: seen ...	2	0
	Limestone, grey, flaggy, a somewhat prominent bed: locally contains pebbles and locally is bored: not ironshot, but some of the joint faces have a ferruginous staining ...	1	3
	[*Non-sequence*]		
Tilestone	Limestone, somewhat rubbly, sandy to the touch, with associated sandy matter; brown where unweathered, weathers white; *Entolium demissum* (Phill.) rare	3	8
	Oolite, yellowish, weathers white and rather soft: contains numerous beautifully rolled pebbles of oolite: top-portion bored in places. Plant-remains, an echinoid, rolled tooth of *Hybodus*, and a *Natica* (?): seen ...	3	6
	(A quarryman said that similar rock extended lower for about	1	6
Snowshill Clay	and that then came a 'tough greenish clay'.)		

Clay ground occurs at a slightly lower level round from west to north and clay throws out the shallow seated spring that is collected and piped to the tap at The Double Lodges. Westward, below the level of the clay, is ample evidence of Harford Sands. Some 660 yds. to the westward of the Five Mile Drive Quarry is an old quarry, now mostly overgrown; but from pieces of freestone (Upper Freestone)—after much searching—the writer and Dr. F. B. A. Welch obtained a few specimens of *Terebratula fimbria* J. Sow. and a single specimen of a *Rhynchonella* (? an immature *R. subobsoleta* Dav.).

The Holt Quarry, near Blockley

		Ft.	Ins.
Tilestone	(In the south-east corner of the quarry). Limestones, sandy, mainly much broken and mixed with yellow marl. Near the base is a fairly regular bed in which specimens of *Lucina* are not uncommon: seen	5	0
	Conglomerate Bed. *Entolium demissum* (Phill.)	1	0
	Limestones, sandy, irregularly bedded, with brown sandy marl partings	2	0
	Limestones, grey, sandy, with partings of sandy and marly matter, as a whole weathering wedge-bedded with prominent deposits of grey to grey-white sand. Plant-remains	10	0
Snowshill Clay	Clay, black, green and blue-grey, tenacious: seen	1	6

This is Buckman's ' Section ix.—Upton Wold Farm, Blockley . . .'[1] Buckman queried the top-portion as being Harford Sands and of the lower 13 ft. said it ' may be a local condition of Upper Freestone ; but if Harford Sands, it indicates a very great thickening of the deposit.' (Pl. III., A.)

In 1904 the writer considered that all the limestones and sands seen here were Harford Sands, and under this impression named the clay below ' Blockley Clay.' This view has been found to be erroneous, so the section given in the report of the Geologists' Association ' Excursion to the Vale of Evesham and the North Cotteswolds' requires amending accordingly.[2] Petrological examinations of the Tilestone sand and Snowshill Clay have been made by J. G. A. Skerl.[3]

About 600 yds. from The Holt Quarry down the road in the direction of Blockley is a disused quarry completely surrounded by a wall. The writer, in company with Dr. F. B. A. Welch, found some poorly-preserved specimens of *Terebratula fimbria* J. Sow. in the upper portion of the limestones displayed : this ' find,' in conjunction with the thickness of the limestone, shows that the rock is Lower Freestone—and not Tilestone, as the writer at one time opined[4] —and the clayey matter above ' wash ' of Oolite Marl and not Snowshill Clay.

About 300 yds. further down the road is a barn, and, between it and Dovedale Farm, an old quarry.

Dovedale Farm Quarry, Blockley

		Ft.	Ins.
Tilestone	1. Flaggy, shelly, oolitic, stone ; *Ostrea*. May have slipped a little, but not much.		
Snowshill Clay	2. Blue and yellow clays, arenaceous near the base : seen about ...	4	0
Harford Sands	3. Greyish sandstone, with small flakes of muscovite ; forms a conspicuous bed	2	10
	4. Parting of rubbly stone with a little sand : 1 to 4 ins.	0	2
	5. Greyish yellow oolitic stone, under surface irregular	1	2
	6. Yellowish brown sand, a few ooliths	0	7
	7. Yellowish oolitic limestones ...	1	7
	8. Yellowish parting of rubbly stone ...	0	3
	9. Grey and very slightly oolitic limestone : seen	0	6

' Yellow Stone ' is quarried to the north of the road on the outskirts of Blockley ; is seen in an old quarry (and road to the S.W.) a little less than ⅓-mile S.S.W. of the Church, Blockley ; and used to be ' mined ' at the now completely overgrown Tally Ho Quarry close to the west side of the road about half-way between Blockley and Bourton on the Hill.

Bourton Quarries, Bourton on the Hill

		Ft.	Ins.
Lower Freestone	White Rock. False-bedded oolite, burnt [at one time] for lime, and used for rough inside walling : 11 ft. to	12	0

[1] *Quart. Journ. Geol. Soc.*, vol. lvii, 1901, p. 135.
[2] *Proc. Geol. Assoc.*, vol. xviii, 1904, p. 398.
[3] *Trans. Worcs. Nat. Club*, vol. viii, pt. 2 for 1924 (1925), pp. 98, 99.
[4] *Proc. Geol. Assoc.*, vol. xviii, 1904, p. 396.

		Ft.	Ins.
Pea Grit Series Equivalent	Earthy sand	2	6
	Red Bed. Hard and rough oolitic limestone, with irregular ferruginous bands ; used for foundations ...	5	0
	Yellow Bed. Buff oolite ; good freestone	6	0
	Ferruginous oolitic limestone with irregular cavities	10	0
	Bottom Beds. Brown sandy and oolitic limestones : 5 ft. to	6	0

H. B. Woodward obtained a specimen of *Hinnites abjectus*,[1] and there have also been collected *Pseudoglossothyris simplex* (J. Buckman), *Terebratula sp.*, *T. submaxillata* auctt., *Rhynchonella subangulata* Davidson, *Zeilleria circularis* S. Buckman and Polyzoa.

At ⅔-mile W. by N. of St. Lawrence's Church, Bourton on the Hill, is a quarry now known locally as the ' Roadstone Quarry.' The section in it was noticed by H. B. Woodward in 1894 (quarry ' North of Bourton Clump '),[2] and was described in detail by S. S. Buckman in 1901 (' Section x.—Bourton Clump ').[3]

Roadstone Quarry, Bourton on the Hill

		Ft.	Ins.
Clypeus Grit and ? trace of Upper Trigonia Grit	Soil and rubble (pisolitic) ; *Gresslya sp.* *Entolium demissum* (Phillips), *Pecten* cf. *anomalus* Terquem & Jourdy, *Pholadomya sp.*, *Rhynchonella acutiplicata* Brown, *Terebratula globata* auctt. : seen	2	6
	[*Non-sequence* : deposits of *niortensis-discitae* hemerae (inclusive) absent]		
Tilestone	Limestone, oolitic—similar to rock above the Conglomerate Bed in The Holt Quarry (see p. 67) : seen ...	4	0
	Faulted, by a fault of small throw, against		
Snowshill Clay	Clay, tough, greenish-grey and blue, locally weathering to a chocolate colour, but passing down into Clay, practically a black shale (as in the well near Ford, p. 60) : 6 to 8 ft. ...	7	0
	Clay, brown and yellow, with layers of pure grey clay (2 ins.thick) at base	0	5
	Stone	0	2
	Brown sand, grey clay, and brownish clay, pocketed into bed below : 6 to 12 ins.	0	9
Harford Sands	Sand, brown, locally blue-grey ...	1	0
	Sand, soft, yellow and grey	1	6
	Sandstone, massive	1	8
	Sand and sand-rock : seen	0	8

At ⅓-mile to the W. of the Roadstone Quarry is one ' in work ' in which Chipping Norton Limestone is exposed to a depth of 12 ft.

A trace of Chipping Norton Limestone is seen above typical Clypeus Grit in a mostly overgrown small quarry in the angle made by the Bourton on the Hill and Stow on the Wold roads just west of the third milestone (west of

[1] ' Jurassic Rocks of Britain ' (*Mem. Geol. Surv.*), vol. iv, 1894, p. 143.
[2] ' Jurassic Rocks of Britain ' (*Mem. Geol. Surv.*), vol. iv, 1894, p. 143.
[3] *Quart. Journ. Geol. Soc.*, vol. lvii, 1901, p. 135.

Bourton on the Hill) from Moreton in Marsh. Debris of the same rocks is seen in the northern angle of the road-bounded triangular tract immediately to the north. In the eastern angle of this triangular tract a trial-boring for water for Moreton in Marsh was made about 1911. T. Gill, of Bourton on the Hill, furnished me with the following details :—

Slate Barn Boring

		Thickness Ft.	Depth Ft.
'[From a few feet above the base of the Chipping Norton Limestone to the top of the Clay] ...	Rock	40	40
[Snowshill Clay]	Clay	8	48
[From top of Harford Sands (or base of Snowshill Clay) to Cotteswold Sands]	Rock : about	200	248
[Cotteswold Sands]	Midford Sands.'		

This boring gives a thickness for the beds between the Chipping Norton Limestone and Snowshill Clay—about 40 ft.

The top of the Snowshill Clay is at about 780 ft. above Ordnance Datum. Thereabouts it crops out in the valley of the River Dikler and tributary coombs to the west, and throws out springs near Upton Wold Cottages ; ' Far ' Upton Wold (in the wood to the north of the house) ; on the valley side east of ' Far ' Upton Wold (where, well below the springs in the stream-course down which the water of the principal one flows, is seen the ' Yellow Stone ') ; etc.

On the edge of Bourton Downs west of Bourton Hill House is this section :—

' Sand Hole,' W. of Bourton Hill House

		Ft.	Ins.
Snowshill Clay	Soil and brown clay : about ...	1	6
Harford Sands	Sand, loose, yellow in places sand-rock	1	0
	Sandstone, hard, decalcification producing a curious coralloid structure of carbonate of lime on the surface ...	1	6
	Sand, loose, yellow : seen	3	0

At ¼-mile N.E. by E. of Bourton Hill House, Harford Sands have been turned out by rabbits, while a little above is a ' well ' in Snowshill Clay catching water running out of Tilestone of which pieces are seen lying about. The Tilestone is sandy and gives rise to a sandy soil (beloved by moles)—above the level of the Snowshill Clay which throws out a spring near the junction of the road from Bourton Hill House with that to Warren Farm—in the field best described as above the ' n ' of Bourton in Bourton Hill House on the 1-inch Ordnance Survey Map, Third Edition, Sheet 217.

In a spur in the valley ½-mile N.N.W of Bourton Hill House there is seen :—

	(In S.E face of spur) :—
Lower Limestone	Limestones, massive, largely composed of fragments of echinoid (? *Acrosalenia*) radioles and isocrinoid ossicles :
	(a little below) :—
Scissum Beds	Limestones, brown, sandy ; large ammonite (? *Pachylytoceras sp.*) *Rhynchonella subdecorata* (rare), *Terebratula* cf. *trilineata* Young & Bird (common in clusters) :
	(and below)
	Sands, loose, brown—decalcified Scissum Beds.

From the side of the valley running up to, and to the south of, Springhill, springs are thrown out by the Snowshill Clay at and at a little below the 800-ft. contour-line. It is known that the Snowshill Clay is the out-throwing deposit because rubble of Clypeus Grit is always found at a higher level: for example, rubble of Clypeus Grit and pieces of the 'Bored Bed' of the Notgrove Freestone are abundant on the northern portion of the field between Smallthorns and the cottage to the north-eastward.

On the south side of the high ground, from which the springs referred to in the last paragraph break out on the north, which overlooks the Horn's Leazor valley, clay occurs at 40 ft. down at Bourton Hill Farm (as proved by a well)[1]; throws out a spring and is reached by a well 6 ft. deep at Smallthorns; and throws out springs (*a*) about halfway between Smallthorns and Snowshill Hill (the water of which is piped to Horn's Leazor), and (*b*) at Snowshill Hill. About 260 yds. S.W. by S. of Bourton Hill Farm; 440 yds. S. of Smallthorns, and 500 yds. S.W. by W. of Snowshill Hill, at a lower level than the clay throwing out the springs, are quarries in Chipping Norton Limestone. A fault clearly intervenes and if its apparent course be extended to the westward it will come between the Oolite Marl exposure thirteen-sixteenths of a mile E.S.E. of Snowshill and the Chipping Norton Limestone exposed in the old quarry near the pond close at hand to the south but at a lower level. By this pond is clay: probably it is Upper Estuarine Clay. This probability makes it desirable to record that some of the clay in the northern portion of the field between Horn's Leazor and Snowshill Hill may be Upper Estuarine Clay faulted against Snowshill Clay.

About ½-mile down the valley of the River Dikler from Bourton Hill House is Warren Farm. A little to the southward of the farm the road makes a bend across a valley known as 'Blessed Bottom.' Alongside the southern part of the bend is a small quarry in 'Yellow Stone' (top portion) and Lower Freestone (bottom portion); while alongside the northern portion is a small quarry exhibiting:—

Blessed Bottom Quarry

		Ft.	Ins.
Oolite Marl	Limestone rubble and marl—disturbed; *Rhynchonella lycetti* Dav.; *Zeilleria leckenbyi* (Walker): say	2	0
Lower Freestone	Limestones, in fairly massive beds with occasional partings of yellow marl: seen	10	0

Hull said that the Oolite Marl 'may . . . be observed at Condicote'[2]: possibly it was here.

The picturesque 'Hinchwick Pools' are on Upper Lias clay: in the banks alongside them is much yellow sand.

In the northern portion of the field E.N.E. of 'New' Hinchwick, in which are situate the old camp and tumulus, the rubble on the field is mostly Upper Trigonia Grit, but pieces of the 'Bored Bed' of the Notgrove Freestone, containing *Variamussium pumilum* (Lamarck), also occur.

In the deep valley east of the camp, between the camp and Hans Brake, is much sand. Associated with the yellow sand is rubbly sandy limestone containing *Variamussium pumilum* (Lamarck) and *Spiropora annulosa* (Michelin). The bulk of the sand here would appear to be Cotteswold Sands; the lesser part, *plus* the fossiliferous sandy limestone, Scissum Beds.

[1] Buckman, S. S., *Quart. Journ. Geol. Soc.*, vol. lvii, 1901, p. 138.

[2] 'The Geology of the Country around Cheltenham' (*Mem. Geol. Surv.*), 1857, p. 37.

On the south margin of Hans Brake, close to the side of the path to Sezincote Hill, is a disused quarry in which Lower Freestone—weathering flaggy—is exposed to a depth of 10 ft.

Sezincote Hill is an interesting locality. In the field east of the barn is a quarry showing :—

Sezincote Hill Quarry

		Ft.	Ins.
Snowshill Clay	Trace of clay (as at pond) ... ... [*Non-sequence* : Harford Sands absent]		
Upper Freestone	Yellow marl and stone (imperfectly exposed) : about	1	8
	Limestone, somewhat rubbly ; *Terebratula fimbria* J. Sow., *Rhynchonella tatei* Dav., abundant...	1	8
	Yellow marl with numerous fragments of oysters ... ... [*Non-sequence* : Oolite Marl (proper) absent]	0	6
Lower Freestone (Basal portion)	Limestone, oolitic in places, obscurely so in others. Surface of top-bed waterworn ; bored in places ...	6	6
' Yellow Stone '	Limestone, yellowish, fairly massive bedded. Surface of top-bed waterworn : seen	0	9

At the pond by the barn is seen clay—Snowshill Clay.

The well under the windpump revealed :—

		Ft.	Ins.
Tilestone	Soil and stone	2	0
	Brown sandy clayey ' marl '	1	6
	Limestone, yellow	3	0
Snowshill Clay	Clay, bluish-grey weathering brown ...	1	0

In the sides of the cart-track some 10 yds. to the S.E. of the well is seen :—

Chipping Norton Limestone	Rubble.
Clypeus Grit	Typical ; *Rhynchonella sp.*, *Pleuromya goldfussi* (Lycett). [*Non-sequence*]
Tilestone	Brown sandy clayey ' marl.'
	Limestone, sandy, somewhat rubbly.
Snowshill Clay	Clay, throwing out spring which maintains pond, the overflow from which sinks into the ground.

At this locality, therefore, no deposits intervene between the Clypeus Grit and Tilestone

At ⅔-mile E.S.E. of Sezincote Hill is the Longborough Quarry of which the following record is by H. B. Woodward[1] :—

Longborough Quarry, Longborough

	Ft.	Ins.
Fissile and false-bedded shelly oolite, like the slaty beds of Hyatt's Pits [Chipping Norton Limestone] ; with pisolitic band near the middle	8	0
White freestone 6 ft. to	7	0
Freestone, shelly in places, with concretionary patches and veins (Red and Yellow freestones) 9 ft. to	10	0

[1] ' Jurassic Rocks of Britain ' (*Mem. Geol. Surv.*), vol. iv, 1894, p. 143.

From the ' Yellow Stone' the writer has obtained *Terebratula submaxillata* Morris (Dav.) (dwarfed), *T. withingtonensis* S. Buckman, *Rhynchonella* cf. *subangulata* Davidson (small form) ; and loose—probably from the Lower Freestone—one *Terebratula fimbria* J. Sowerby.

' Yellow Stone ' is seen in a small quarry at the turning to Longborough from the Stow road just south of the Longborough Quarry (where *Rhynchonella* cf. *subangulata* Davidson (small form) occurs throughout the rock, which also contains *Nerinaea spp., Terebratula sp., Rhynchonella* cf. *subangulata*-group) ; and in a small quarry ½-mile S.S.W. of Sezincote—near the reservoir for Sezincote, where it contains similar brachiopods, with the addition of *Terebratula ? plicata* J. Buckman ; *Gresslya sp.*, and *Natica sp.*

H. B. Woodward said :—' The thickness of the Inferior Oolite, proved in a well at the Worcester Lodge, Batsford Park, north-west of Bourton on the Hill, was 160 ft.'[1]

The well referred to is at the Worcester Lodge of Sezincote, not Batsford Park : it is not used now as water is forced up by a ram from a spring thrown out by the Upper Lias clay at the bottom of Blessed Bottom, near Warren Farm, in the valley of the Dikler.

Rubble of typical Clypeus Grit is seen in an overgrown shallow working close to the east side of the Broadway-Stow road S.E. by S. of Worcester Lodge, and debris of Chipping Norton Limestone in the almost completely overgrown quarry on the west side of the road facing the Lodges, so it would appear that the thickness of the Inferior Oolite here is about 160 ft.

The ' District Well ' at the Stow on the Wold Urban District Council's Waterworks in the town probably commences in Great Oolite. As the thickness of this rock cannot be much and the well reaches the Upper Lias, the depth of the well 130 ft., gives an idea of the thickness of the Inferior Oolite *plus* Chipping Norton Limestone beneath the town.

From excavations made at the Boys' Council School, Stow on the Wold, were obtained pieces of Lower Limestone packed with specimens of *Variamussium pumilum* (Lamarck).

In the Fosse Way or ' Moreton Road ' cutting and in quarries in the vicinity about ¾-mile northward of Stow on the Wold the following sequence can be made out :—

Quarry, ' in work,' in field west of Fosse Way cutting

		Ft.	Ins.
	Tip of former working	3	0
Chipping Norton Limestone	Limestone, very fine-textured ; oysters (rare), plant-remains...	6	0
	Limestones, in about three massive beds : seen		
	(In Fosse Way cutting west side) :—		
Chipping Norton Limestone	Limestones, as in quarry, but passing down into	12	0
	Limestones, more sandy, with shaly partings		
	Limestones, yellower, oolitic and sandy : ' brown plant-remains ' (*cf.* Hook Norton Beds) : seen	4	0
	(Now obscured but seen in 1904) :—		
Roundhill Clay	Clay, grey and yellowish, with ooliths, containing a few pebbles, lignite, and specimens of *Ostrea*. Soft oolitic stone often replaces this clayey deposit : about	0	6

[1] *Idem*, p. 143.

		Ft.	Ins.
Clypeus Grit	Limestones, rubbly, oolitic ; somewhat unfossiliferous, but yielded a single specimen of *Clypeus ploti* Klein, and several *Terebratulae* of the *T. globata* auctt. type : seen	3	0
	(Exposed) :—		
Clypeus Grit	Typical : seen	4	0
	(Now obscured, but seen in 1904) :—		
Clypeus Grit	Typical, resting on		
Freestone	Limestone, flaggy, oolitic ...	A few feet	
	(In cutting, lower down east side) :—		
' Yellow Stone '	Limestone, yellow, iron-stained, oolitic, slightly sandy towards the base : seen	2	6
	(In the Triangle Quarry) :—		
Superficial Deposit	Reddish soil with a few ' Northern Drift ' pebbles : up to	1	0
Clypeus Grit	Limestone, rubbly, slightly less oolitic and pisolitic than usual ; usual fossils : seen ... ... [*Non-sequence* : deposits of *truellei—murchisonae* (late) hemerae (inclusive) absent]	4	6
' Yellow Stone '	Limestone, fine-grained, yellow : seen	2	0

Clypeus Grit was formerly worked by the east side of the road-cutting. Hull said[1] :—' At Stow, there is an excellent section of these beds, a little way north of the town on the Moreton Road, where they are quarried for road material. It is there a very coarse-grained oolite, containing large numbers of the *Clypeus* and other fossils ; and in this locality rests directly on the sands of the Upper Lias, being, in fact, the only remaining member of the Inferior Oolite.' Probably Hull regarded the few feet of ' Yellow Stone ' as representing a part of the ' sands of the Upper Lias.'

Sections on and near the Banbury and Cheltenham Railway between Andoversford and Bourton on the Water.—Certain sections on and near the Banbury and Cheltenham Railway between Andoversford and Bourton on the Water will now be considered.

In the first cutting east of Andoversford Station, near Syreford Farm, the following section has been recorded by S. S. Buckman[2] :—

	Ft.	Ins.
1.—Several bands of sandy rock with sandy partings ...	8	0
2.—Yellowish sandy debris, occasionally hardening into coarse stone	2	6
3.—Band of rock	1	0
4.—Sticky, yellowish brown sandy debris	3	0
5.—Bands of a rough decomposed limestone, with shelly matter	3	0
6.—Coarse fissile kind of white freestone, with white oolite grains. Lamellibranchiata, small Gasteropoda, etc., visible	10	0 '

[1] ' The Geology of the Country around Cheltenham ' (*Mem. Geol. Surv.*), 1857, p. 46.

[2] ' The Inferior Oolite between Andoversford and Bourton-on-the-Water,' *Proc. Cotteswold Nat. F.C.*, vol. ix, pt. 2, 1887, p. 120. See also Woodward, H. B., ' Jurassic Rocks of Britain ' (*Mem. Geol. Surv.*), vol. iv, 1894, p. 130.

Buckman at first regarded the beds as Harford Beds, but subsequently correlated them with the Sandy Beds composing the top-portion of the Pea Grit Series.[1]

Between this cutting and the Stow road is a long cutting in which is displayed :—

		Ft.	Ins.
Upper Trigonia Grit	Ragstone ; *Trigoniae* (casts), *Rhynchonella acutiplicata* (Brown), *Terebratula globata* auctt., *Zeilleria hughesi* (Walker) : seen	6	0
	[*Non-sequence* : deposits of *niortensis-witchelliae* (late) hemerae (inclusive) absent]		
Notgrove Freestone	Limestone, hard, oolite ; top-portion bored, level surface covered with oysters : seen	14	0

Between the Stow road and the Salt Way is the deep cutting through Hampen Hill in which the sequence from the Fullers' Earth to, and inclusive of, the White Limestone subdivision of the Great Oolite is displayed (see p. 103).

Then north-west of Salperton comes the cutting through the Stonesfield Slate Series (see p. 110).

Between the embankment that carries the railway over the valley north of Salperton and Notgrove Station is a cutting in which is the section thus described by S. S. Buckman[2] :—

First Cutting West of Notgrove Station (North side)		Ft.	Ins.
[Fullers' Earth.—Basal portion]	UPPER ESTUARINE CLAY. Tough, grey-green : seen about	1	0
	[*Non-sequence* : Neaeran Beds and Chipping Norton Limestone absent]		
Clypeus Grit	Rubbly limestone, pisolitic ; *Terebratula globata* auctt., common : about	0	6]
	' B ? 1. Fossiliferous stone, with horizontal fracture in layers ...	4	0
	C. 2. Stone like lower portion of Clypeus Grit, but harder, *Clypeus Plottii* abundant ...	3	0
	3. Rotten stone, in fact a paste of oolitic grains, clayey, with crushed variety of *T. globata*	2	0
	4. Yellow stone, upper part of a more Freestone nature, lower rubbly, with irregular cleavage. *T. globata* abundant ...	31	0
	[*Non-sequence* : Upper Coral Bed and Dundry Freestone absent]		
[Upper Trigonia Grit]	D. 5. Trigonia grit, 3 beds separated by marly partings, topmost lighter and much harder. *Rh. hampenensis* in clusters, *Wald. Hughesi*, *Am. Parkinsoni*, impressions of *Trigonia* abundant	4	6
	[*Non-sequence* : deposits of *niortensis-witchelliae* (late) hemerae (inclusive) absent]		

[1] *Proc. Cotteswold Nat. F.C.*, vol. x, pt. 1, for 1889-1890, 1890, p. 95.

[2] *Proc. Cotteswold Nat. F.C.*, vol. ix, pt. 2, 1887, p. 123.

			Ft.	Ins.
[Notgrove Freestone]	E.	6. Bored Bed. Thickness variable and not always separated from Freestone below	0	8
		7. White freestone, rather soft and fairly uniform, no partings ...	12	0
[Gryphite Grit]	F.	8. Five or six beds of thinnish, somewhat rubbly stone, hard, white coloured, softer partings	7	0
		9. Two beds with occasional *Gryphaea sublobata*	2	4
		10. Bed with *Gryphaea sublobata* abundant, visible	1	6'

My additions are given in square brackets. The Fullers' Earth clay and rubbly limestone layer with *Terebratula globata* auctt. above Buckman's 'fossiliferous stone' were seen at the eastern end of the north side of the cutting. The occurrence of Upper Estuarine Clay on the Clypeus Grit without the intervention of any Chipping Norton Limestone is in accord with the section in the Lime Hill Wood Quarry (p. 54).

The following section is by S. S. Buckman[1]:—

First Cutting, East of Notgrove Station (North side)

			Ft.	Ins.
"[Harford Sands]	H.	1. Soil and Rubble, lower part light coloured unfossiliferous stone, in small slabs	2	6
		2. Bright Yellow Micaceous Sands, fine [weather loose]	1	3
		3. Sandy stone	1	9
[Upper Freestone]	I.	4. Soft partly Oolitic Marly debris, small *Rhynchonella* (scarce) ...	2	2
		5. Sandy stone	0	7
		6. Soft Marly parting	0	6
		7. Sandy stone (two bands) with Marly parting	1	1
		8. Loose, soft, white, blue, or yellow Marl	2	8
		9. Sandy stone	0	7
		10. Marly parting	0	3
		11. Loose shattered sort of Freestone, rather harder at the top	5	0
		12. Band of hard stone	0	4
[Oolite Marl]	J.	13. Blue clayey marl	3	10
		14. Band of hard stone	0	5
		15. Yellow clay	0	8
		16. Yellow clay, often deep blue, like Upper Lias. *Rhyn. obsoleta* bed. *Tereb. fimbria*	1	8
		17. Coral bed, according to Mr. Witchell, with *Lima pontonis, Trigoniae, Corals*, etc.	3	2
		18. Hard white rock (variable, somewhat of a Ragstone nature of bedding. *Rhynch. sp., Rh. Lycetti*, scarce)	5	9

[1] *Proc. Cotteswold Nat. F. C.*, vol. ix, pt. 2, 1887, pp. 113, 114.

		Ft.	Ins.
[Oolite Marl]	19. Shaly pasty rock, *T. curvifrons* abundant. *W. Leckenbyi* scarce. *Rhynchonellae*	2	0
	The same cutting, South side		
	20. Hard stone, *Tereb. submaxillata* abundant	2	0
	21. Whitish pasty rock, becoming clayey on exposure, very fossiliferous. *Wald. Leckenbyi, Rh. Lycetti, Wald. Witchelli, Tereb. Notgroviensis, Tereb. plicata, Tereb. Whitakeri*	1	10
[Lower Freestone]	22. Hardish Oolitic rock, pale pink tinge, very flat on the top; visible	0	8"

Buckman says :—' [Bed] No. 21 is most interesting for the fauna that it contains (I have found that the fauna of each bed is more or less different to the others), which is more varied and abundant than that of any other beds. No. 20 contains only *T. submaxillata*, . . . I have not found *Tereb. curvifrons* lower than No. 19, where it is fairly abundant. No. 17 was identified by Mr. Witchell as the equivalent of the Coral Bed of the Stroud area. No. 16 is interesting for the great quantity of *Rhynchonella subobsoleta* which it contains. I have not found this shell at all lower, and the same remark applies to *Tereb. fimbria*, a fossil usually (but perhaps not correctly) supposed to be characteristic of the whole of the Oolite Marl. The other beds are not particularly noticeable, except that I have observed *T. fimbria* in bed 11, and that in No. 4 I found a few small *Rhynchonellae* of the *Rhynchonella subangulata* type. These shells are not yet named, but seem to mark a definite horizon some little way above the bed with *Rhynchonella subobsoleta* for I have found them in the Stroud district in the same position. They usually go under the name of *Rhynchonella cynocephala* var., are of two or three forms, and could probably be well separated from that species.'

According to S. S. Buckman[1] ' Just beyond the bridge a fault, which crosses the line obliquely (N.W. to S.E.) brings down the upper beds of the Inferior Oolite, viz., the Clypeus Grit, [Upper] Trigonia Grit, and Notgrove Freestone level with the Oolite Marl. A few yards further on eastwards these beds are all bent downwards at about 45 degrees, and another fault brings the Fullers' Earth down to the same level.'

The second fault cannot be clearly seen now as the eastern end of the bank is obscured by grass.

It will be observed that the beds classified as Upper Freestone are much more marly than usual. Bed 2 of the Harford Sands is easily located : it has weathered to a loose sand.

In the bank of the valley south of the signal-box at Notgrove Station is a small quarry, ' in work,' in the ' Yellow Stone ' ; and, below it, to the S.S.W. —near the 700 ft. contour-line—brown sands (probably mainly decemented Scissum Beds) have been thrown out by rabbits.

From the bank at the ' Yellow Stone ' quarry clear evidence is obtainable for the fault shown on the map, for whilst this quarry is in a low subdivision of the Inferior Oolite, the almost overgrown small quarry in the field some 200 yds. to the south-westward, at a much lower level, is in the highest subdivision—the Clypeus Grit.

Harford Sands (fine-grained sandy limestone and sand) succeeded by traces of Snowshill Clay, are seen in an opening in the ground south of the road

[1] *Proc. Cotteswold Nat. F.C.*, vol. ix, pt. 2, 1887, p. 114.

bridge over the Notgrove railway-cutting and west of Notgrove Long Barrow. Probably it is the Snowshill Clay that throws out the spring in the field north of Notgrove Station, the water of which has been collected and piped to the standpipe by the road-side immediately north of the station.

Upper Trigonia Grit (5 ft.) and Notgrove Freestone (3 ft. 6 ins.) are worked for road-metal in a quarry in a field on the right hand side of the road to Bourton on the Water, ½-mile E. by S. of Notgrove Station.

The second cutting east of Notgrove Station, mostly overgrown, showed—according to H. B. Woodward[1]—the base of the Taynton Stone, Stonesfield Slate Series, and (at the eastern end) the top of the Fullers' Earth.

The third cutting—a short one, mostly overgrown—is through the same beds, only the Fullers' Earth showed at the west end and the Taynton Stone came on at the east end.

The fourth cutting—a small one—displayed the top of the Stonesfield Slate Series and a little of the overlying Taynton Stone.

The fifth cutting, east of Aylworth, is through Taynton Stone, which is well exposed.

The sixth cutting is the interesting Roundhill Cutting, the section in which is described on p. 112. The deposits in the neighbourhood of the junction of the Chipping Norton Limestone and Fullers' Earth are not now satisfactorily exposed in this cutting, but their probable nature is shown by a useful section in the quarry close to Roundhill Farm a third of a mile distant to the north-west.

The seventh cutting east of Notgrove Station is Buckman's 'Fourth Cutting West of Bourton.'[2] Adjoining it on the south is Roundhill Fox Covert.

Roundhill Fox Covert Cutting

		Ft.	Ins.
Clypeus Grit	At the top, typical, 'marly' and rubbly; passing down in the median portion into more bedded rock; and in the lower portion into somewhat nodular-looking rock: seen	30	0
	[*Non-sequence*: Upper Coral Bed and Dundry Freestone absent]		
Upper Trigonia Grit	Ragstone; usual fossils	3	3
	[*Non-sequence*: deposits of *niortensis-witchelliae* (late) hemerae (inclusive) absent]		
Notgrove Freestone	Limestone, hard, oolitic; top-portion bored, surface level and covered with oysters: seen	5	4

The next cutting is Buckman's 'Third Cutting West of Bourton on the Water.'[3] The rocks displayed in it (see below) are displaced by a multitude of small faults, as has been very clearly brought out by H. B. Woodward in his representation of the section.[4] Buckman's measurements were checked by the writer. The principal difference between Buckman's record and that here given is that his bed G (his Lower Trigonia Grit) has been separated into Buckmani Grit, Lower Trigonia Grit, and Tilestone. The Buckmani Grit is sandy-rock; the Lower Trigonia Grit, whitish, marly, rock, with ferruginous

[1] 'The Jurassic Rocks of Britain' (*Mem. Geol. Surv.*), vol. iv, 1894, pp. 131, 294.
[2] *Proc. Cotteswold Nat. F.C.*, vol. ix, pt. 2, 1887, p. 124.
[3] *Idem*, p. 118.
[4] 'Jurassic Rocks of Britain' (*Mem. Geol. Surv.*), vol. iv, 1894, p. 131.

ooliths. Buckman presumed that the rock classified in the following record as Tilestone was that rock.[1] In addition to a reading at the west end of the cutting, Buckman took one at the east end[2] and a comparison of the two reveals that whereas at the west end the Notgrove Freestone is 8 ft. thick, at the east end it is only 1 ft. thick.

Third cutting, West of Bourton on the Water (*South side* : *West end*)

		Ft.	Ins.
Clypeus Grit	1. Rubbly and marly at the top passing down into more massive typical Clypeus Grit : crowded with specimens of *Terebratula globata* auctt. and *Pleuromya spp.* in bands : seen ...	12	0
	[*Non-sequence* : Upper Coral Bed and Dundry Freestone absent]		
Upper Trigonia Grit	2. Ragstone hard in three beds ; *Rhynchonella hampenensis* S. Buckman in clusters	3	2
	[*Non-sequence* : deposits of *niortensis-witchelliae* (late) hemerae (inclusive) absent]		
Notgrove Freestone	3, 4. Limestone, hard grey oolitic, top portion bored, level surface (making a noticeable feature in the cutting) with oysters adhering	8	0
Gryphite Grit	5. Limestone, sandy ; echinoderms, casts of *Cucullaea sp.*	1	6
	6. Limestone sandy, with *Gryphaea sublobata* auctt. abundant ; *Entolium demissum* (Phillips) ...	1	6
Buckmani Grit	7. Limestone, rubbly sandy ; *Cucullaea sp.*	0	10
	8. 'Marl' pale yellow sandy with traces of clay ; *Terebratula buckmani* Davidson, *Trigonia sp.*	0	6
	9. Limestone grey sandy. *Entolium demissum* (Phillips), common at the top	1	8
	10. Limestone, hard	1	0
	11. 'Marl' light brown sandy ...	0	6
	12. Limestone hard sandy, weathering brownish ; *Entolium demissum* (Phillips)	1	4
Lower Trigonia Grit	13. Limestone, marly, whitish, with ferruginous ooliths ; *Myoconcha sp.*, etc.	0	10
Tilestone	14. Limestone, hard, somewhat crystalline, with light yellow ooliths in a brown matrix	2	8
	[*Non-sequence* : Snowshill clay absent]		
Harford Sands	15. Sands, yellow, with a considerable admixture of clay matter ...	1	0
	16. Band of stone	1	10
	17. Floor of cutting, fine yellow sand.		

[1] *Quart. Journ. Geol. Soc.*, vol. lvii, 1901, p. 137.
[2] *Proc. Cotteswold Nat. F.C.*, vol. ix, pt. 2, 1887, p. 118.

To the north of this cutting the River Windrush makes a northward bend. A path climbs over the northward-projecting hill spur, and at the point—some 300 yds. N. of the cutting—where this path makes a right-angle bend the writer has found specimens of *Rhynchonella tatei* Davidson. This brachiopod characterizes the upper portion of the Upper Freestone at the Frith Quarry, near Painswick.

The next cutting proceeding eastwards is near Aston Farm ; it is Buckman's ' Second Cutting, West of Bourton-on-the-Water.'[1] For the following record the thicknesses obtained by the writer were sufficiently near to those given by Buckman as to make it desirable to adopt the latter. The principal difference between Buckman's record and the present one is that Buckman's divisions F. and G. (his Gryphite Grit and Lower Trigonia Grit) have been separated into Gryphite Grit and Buckmani Grit, Lower Trigonia Grit and Tilestone. Very clear planes of slight erosions are observable at the tops of the Tilestone and Lower Trigonia Grit ; all the subdivisions present between the Upper Freestone and Clypeus Grit are much attenuated, and testify to the unstable conditions prevailing during their hemerae of deposition in this neighbourhood of the anticlinal axis ; and the Clypeus Grit has overlapped the Upper Trigonia Grit.

Aston Farm Cutting

		Ft.	Ins.
Clypeus Grit	1. Rubble of typical Clypeus Grit ; *Terebratula globata* auctt., etc. : seen	5	0
	[*Non-sequence* : deposits of *truellei* (early)-*witchelliae* (late) hemerae (inclusive) absent]		
Notgrove Freestone	2. Limestone, hard, grey, oolitic, bored, top level and covered with oysters ; casts of *Trigoniae* (Clavellate form) on under side	0	7
Gryphite Grit	3. Limestone, rubbly, brown, sandy, with small pectens	0	5
	4. Marly bed with belemnites ...	0	3
Buckmani Grit	5. Limestone, irregular	0	8
	6. Marly parting	0	4
	7. Limestone, hard, sandy, with a very irregular under surface which has attached to or embedded in it many fossils—*Pholadomya fidicula* (J. de C. Sow.), *Pleuromya sp.*, etc., Ammonite—one of the Darellinae, nearest perhaps to *Darellia* ... ... [*Plane of slight erosion.*]	0	11
Lower Trigonia Grit	8. Limestone, rubbly, marly, whitish, with level top ; *Terebratula degenerata* Upton, etc. ...	0	5
	8*a*. Limestone, similar iron-stained, pebbly in places, level top ... [*Plane of slight erosion*]	0	8
Tilestone	9. Limestone, whitish, in two bands, top level and waterworn ; belemnite	2	2
	[*Non-sequence* : Snowshill Clay absent]		

[1] *Proc. Cotteswold Nat. F.C.*, vol. ix, pt. 2, 1887, p. 116.

		Ft.	Ins.
Harford Sands	10. Yellow micaceous sands	0	4
	11. Sandy rock	2	0
	12. Yellow sand	1	4
	13. Sandy rock	1	1
Upper Freestone	14. Marly debris	2	8
	15. Band of rock	1	1
	16. Marly debris with *Terebratula fimbria* J. Sow. and *Rhynchonella tatei* Dav.	0	7
	17. Freestone, with upper portion bored : seen	5	6

In the same cutting, further west, where the beds are elevated, but on the south side, Buckman noted[1] :—

	Ft.	Ins.
' 18. Freestone, fully exposed ...	9	0
19. Hard stone	0	10
20. Marly parting with crushed *Tereb. fimbria*, small crushed *Rhynch.*	0	2
21. Light coloured Oolitic stone, small *Rhynch.*	1	0
22. Brown clayey marl	1	1
23. Very hard whitey-brown stone ...	3	3 '

Buckman observed that one of the chief points about this section ' was the fact of finding that bed 17 had its upper portion slightly bored.'

In the road-cutting at Aston Farm Buckman observed[2] :—' . . . some irregular rubbly rock, with a fine grained Marly debris above, in which I found *Terebratula fimbria*. Altogether about five feet is here exposed.' ' . . . we can easily surmise that the marl with *Terebratula fimbria* underlies at a greater or lesser distance those rocks in that [Aston Farm railway-cutting] section, which by other evidence we know to belong to the Upper Freestone Series.'

About 300 yds. east of this road-cutting, to the north of the line after it has crossed the River Windrush is a quarry exhibiting :—

Clypeus Grit	Traces of slipped rubble ; *Pleuromya goldfussi* (Lycett), *Rhynchonella hampenensis* S. Buckman, *Terebratula globata* auctt., *Anabacia complanata* (Defrance).
	[*Non-sequence*]
? Lower Freestone (base) and Pea Grit Equivalent	Limestone-rubble and disturbed brown sandy limestone full of specimens of *Rhynchonella* of *subangulata* group passing down into disturbed but more massive yellow oolite.

Although the beds are disturbed and the rubble of Clypeus Grit may have slipped a little, the writer is of opinion that here the Clypeus Grit rests directly on beds of *murchisonae* hemerae. This also appears to be the case—except for the intervention of traces of Upper Trigonia Grit—at an old quarry by the side of the Bourton-Notgrove road ⅓-mile to the S.S.W.

Between the River Windrush and Bourton on the Water is a cutting of which Buckman said[3] :—' The part . . . nearest to Bourton seems to be in a hopeless confusion, but as we get above the bridge we find that the beds seem to be more regular, and we are able to make out the following section :—

[1] *Proc. Cotteswold Nat. F.C.*, vol. ix, pt. 2, 1887, p. 117.
[2] *Proc. Cotteswold Nat. F.C.*, vol. ix, pt. 2, 1887, p. 134.
[3] *Proc. Cotteswold Nat. F.C.*, vol. ix, pt. 2, 1887, p. 133.

First Cutting West of Bourton on the Water Station (above the Bridge ; North side)

	Ft.	Ins.
1. Rubbly pale Limestone in small slabs : about	7	0
2. Large irregular blocks of pale brownish limestone, dipping north at an angle of about 40 degrees ...	2–5	0
3. Fine yellow micaceous sands, with slight irregular concretionary nodules, visible	8	0 '

Of the fine yellow micaceous sands he said that they are ' very similar in appearance to what is known as the Cotteswold Sands.' In 1905, when discussing *Pachylytoceras phylloceratoides sp. nov.*, which he presumed to be an ammonite of hemera *scissi*, Buckman said[1] :—' . . . some 20 years ago I saw in the possession of the late Dr. Moore, at Bourton on the Water, several giant parvumbilicate Lytoceratoids which had been obtained during the making of the Banbury and Cheltenham Railway, from the first cutting on the west, presumably from the Sands. That they were Lytoceratoids with phylloceratan aspect attracted my attention at the time.'

E. A. Walford remarked[2] :—' At Bourton the rocks are strangely broken ; and in the railway-section nearest the station, tumbled masses of *Clypeus* grit are to be seen resting upon the Upper Lias with the intervention of merely a few feet of (crinoidal) limestone and sand.'

' Crinoidal limestone ' suggests Lower Limestone Equivalent.

H. B. Woodward said :—' The Cotteswold . . . Sands were shown in the first cutting west of Bourton Station. There 12 to 15 feet of yellow slightly calcareous micaceous sands, with concretions of calcarceous sandstone, were to be seen. *Belemnites, Myacites,* and Serpulae occur in them. The beds rest on blue micaceous loamy clay, and are overlaid by tumbled masses of the Lower Freestone, including flaggy and shelly oolite, and beds like the " yellow freestone " of the northern Cotteswolds. *Pecten personatus,* and *Pholadomya fidicula* were found.'[3]

The Iccomb District.—In the hill-country to the east of the Vale of Bourton, which, for the present purpose, may be designated the Iccomb District, the sequence of Oolitic Beds, in descending order, is :—

	Ft.
Chipping Norton Limestone : seen	10
Roundhill Clay.—Locally present	0–1
Clypeus Grit : about	20½
[*Non-sequence* : deposits of *truellei* (early)—*aalensis* hemerae (inclusive) and the Upper Lias ? down to and including the top-portion of the Fibulatum Zone absent]	

About 1½-miles to the south of the southern limit of the district under consideration, above Great Rissington, is the following important section :—

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[1] ' On Certain Genera and Species of Lytoceratidae,' *Quart. Journ. Geol. Soc.*, vol. lxi, 1905, p. 147.

[2] ' On the Relation of the so-called " Northampton Sand," ' *idem*, vol. xxxix, 1883, p. 225.

[3] ' Jurassic Rocks of Britain ' (*Mem. Geol. Surv.*), vol. iv, 1894, pp. 129, 130.

	Quarry at Great Rissington	Ft.	Ins.
Chipping Norton Limestone	Limestones, brownish, black-speckled.		
	Limestones, rotten-looking, shelly.		
Roundhill Clay	Clay, greenish-grey, with a band of limestone full of *Ostrea acuminata* J. Sow. (3 to 6 ins.[1])	1	0
Clypeus Grit	Rubbly Beds. *a.* Limestone, '*Globata*-Bed'; *Terebratula globata* auctt., and *Clypeus ploti* Klein	0	6
	b. Limestones, rubbly; *Clypeus ploti* Klein, *Terebratula globata* auctt., and *Pholadomya murchisoni* J. de C. Sow.	8	0[2]
	'Massive Beds.' Limestones, more massively bedded; *Clypeus ploti* Klein, *Terebratula globata* auctt.: seen	12	0

When the writer made an examination of the district in 1905, the results of which were given in a paper published in 1907,[3] the faunal and lithic characters of the bed at Great Rissington now identified with the Roundhill Clay led him to conclude that the succeeding limestones—which contain black specks (as does the Chipping Norton Limestone) and occurs over considerable areas in the Rissington—Burford District—was Great Oolite and that the Chipping Norton Limestone was absent. Subsequent work in the Chipping Norton District and recent work in the North Cotteswolds, has revealed that the clay at Great Rissington, designated in his 1907 paper as Fullers' Earth represents only a small basal portion of that formation and is Roundhill Clay, and that the succeeding limestones are Chipping Norton Limestone.

In the Iccomb District, the Chipping Norton Limestone has escaped denudation only in the vicinity of Iccomb Tower: it was represented as Great Oolite on the Geological Survey Map, Sheet 44 (Old Series). Some 10 ft. of it, much broken up, are seen above the Clypeus Grit in a quarry about ½-mile north-westward of Iccomb.

At the turning to Gawcombe from the Stow-Burford road is a quarry 'in work.'

	Gawcombe Lodge Quarry	Ft.	Ins.
Clypeus Grit	Rubbly Beds. *b.* Limestones, rubbly and pisolitic marl; *Terebratula globata* auctt., etc.; *Clypeus ploti* Klein (common): seen	4	6
	'Massive Beds.' Limestones, fairly massively bedded; in the main oolitic, in part pisolitic; weathering white and are 'lime-washed'; few fossils: seen	8	0

Clypeus Grit, mostly the 'Massive-Beds' portion, is displayed (to a depth of 15 ft.) in a quarry on the north side of the road to Wyck Rissington a little to the west of Wyck Beacon.

It is also to be seen (1) now only as rubble, in an old quarry immediately west of Far Hill Barn, below which a spring is thrown out by the subjacent Upper Lias clay[4]; and (2) in an old quarry at the cross roads a little less than ½-mile to the W.S.W.

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[1] Mr. Charles Upton washed some of this clay, and found in it three specimens of *Cristellaria rotulata* Lamarck.

[2] About 8 ft., may be more.

[3] 'The Inferior Oolite and Contiguous Deposits of the District between the Rissingtons and Burford,' *Quart. Journ. Geol. Soc.*, vol. lxiii, 1907, pp. 437-443.

[4] *Quart. Journ. Geol. Soc.*, vol. lxiii, 1907, p. 441.

CHAPTER IV

FULLERS' EARTH

Above the Inferior Oolite comes the Fullers' Earth of *zigzag-acuminatae* hemerae. The Fullers' Earth is generally visualized as a clay formation, but in the district under consideration it is largely replaced by limestone—the Chipping Norton Limestone. Its subdivisions are set out on p. 85.

Roundhill Clay

This clay has been observed, intermittently developed, only where the Chipping Norton Limestone is present above. It has been observed (1) At Martin's Hill, between Stow on the Wold and Oddington (6 ins. thick) (p. 88) ; (2) in the Roundhill Railway Cutting, 1 mile S.E. of Naunton (1 ft. 6 ins. thick) (p. 113) ; (3) near Granny's Bank Coppice, Upper Slaughter parish ;[1] (4) ? near Hinchwick (see below) ; (5) one mile south-eastward of Snowshill (see below) ; and at (6) Great Rissington (see p. 83).

Local Details

Ascending the Buckle Street southward from the small old quarry in the Chipping Norton Limestone tilestone in the dip five-sixths of a mile S.E. by E. of Snowshill, tough Upper Estuarine Clay will be noticed in the deep wheel-ruts ; heavy clay ground about halfway up the field to the east of the road ; and close to the east side of the road south of Snowshill Hill Barn. In April, 1925, excavations for the reception of fence posts were made along the east side of the Buckle Street between Snowshill Hill Barn and the plantation. First typical Clypeus Grit was seen succeeded by yellowish clay packed in places with small oysters of *Ostrea acuminata*-outline but many with *Ostrea subrugulosa*-ornamentation. The clay occupies the stratigraphical position of the Roundhill Clay. There is thus a fault a little to the south of the barn bringing the Upper Estuarine Clay on a level with the upper portion of the Clypeus Grit.

Northward of Hinchwick is the hill-spur known as ' The Warren.' Ascending the southern slope of The Warren spur by the rough track, Lower Freestone will be observed just below the 600-ft. contour-line. Higher up there is ample evidence of Notgrove Freestone with *Variamussium pumilum* (Lamarck), followed by that of Clypeus Grit and Chipping Norton Limestone.

Hinchwick has a piped supply from a spring situate towards the top of the dry valley side 750 yds. to the north of the farm. The fragments of rock lying about near the reservoir, and dug out of the excavation to contain it, are principally of Notgrove Freestone : there are a very few pieces of Clypeus Grit. The spring has been collected and runs out of a pipe at a slightly higher level than the top of the reservoir. So it would appear that the water is thrown out by a higher bed than the Snowshill Clay—? by the Roundhill Clay. There appears to be evidence for Snowshill Clay in the clay-ground below the reservoir : certainly it throws out the spring some 250 yds. to the N.W. by W., where, at a slightly lower level, Harford Sands have been turned out by rabbits.

[1] Richardson, L., ' Excursion to Bourton-on-the-Water . . . ', *Proc. Cotteswold Nat. F.C.*, vol. xvi, pt. 1, 1907, p. 25.

The Great Oolite Series : North Cotteswolds.

Geological Survey.	Subdivisions.		Hemerae.	Chronographic Subdivisions.
Forest Marble	*Ostrea*-Limestone	[*Slight non-sequence*]	*marmoreae*	Bathian
Great Oolite[1]	White Limestone Marly Beds Taynton Stone		*Tulophorites* *hopkinsi* *subcontracti*	Bathian
	Stonesfield Slate Series	[*Local non-sequence*]	[*gracilis*]	Vesulian.
Fullers' Earth	Fullers' Earth (the local) Upper Estuarine Clay Neaeran Beds (traces locally) Chipping Norton Limestone Roundhill Clay	[? *Non-sequence*]	*acuminatae* *fuscae* ? *zigzag*	Vesulian.

[1] The dating of the Great Oolite beds is tentative.

Chipping Norton Limestone

The Chipping Norton Limestone is well developed in the main hill-mass of the North Cotteswolds and is exposed in a large number of quarries in which it is worked principally for road-metal. It varies much in lithic structure from place to place: along the eastern portion of the district (quarry a little more than 1 mile west of Bourton on the Hill; Newpark Quarry, near Longborough; about ½-mile north of Stow on the Wold; and at Granny's Bank Coppice Quarry, Upper Slaughter) it is mainly a whitish oolite with black specks and, locally, numerous well-rolled pebbles of oolite—the product of pene-contemporaneous erosions: at Flagstone and Bolton's Ground Quarry, near Condicote, its upper beds are flaggy; in sand-holes (*a*) between Flagstone and Condicote, and (*b*) ¼-mile W.S.W. of Hinchwick it has partially broken down to a 'sand'; in Bevan's Quarry, 1 mile E.N.E. of Temple Guiting true sand occurs in layers and irregular deposits as the result of decementation, and over considerable areas in the vicinity of Guitinghill Farm and the Ling Ground to the W.S.W. of Horn's Leazor it gives rise to a very sandy soil. Its top portion at Guitinghill Quarry and in a quarry about ½-mile west of Kinetonhill Farm includes curious 'Node Beds'—the 'nodes' being extremely hard segregations of carbonate of lime; and five-sixths of a mile S.E. by E. of Snowshill, friable oyster-limestone in which an abundance of oysters have in association many little pebbles of oolite. At Guitinghill Quarry one sand-deposit passes into a fissile sandy 'slate' suggestive of Stonesfield or Cotteswold 'slate'; in the quarry ½-mile west of Kinetonhill Farm a layer, about the same horizon, yields slates which some attempt has been made to work for roofing purposes. It is interesting to find that as the Chipping Norton Limestone approaches the Eyford district in which 'slates' occur in the Stonesfield Slate Series one layer at least in the Chipping Norton Limestone yields slates which are indistinguishable—if fossils of zonal value are absent—from those from the Stonesfield Slate Series. The difficulty of distinguishing Chipping Norton Limestone with its associated slates from the Stonesfield Slate Series is shown by the fact that Hull represented the rocks along a tract south of Kinetonhill Farm as belonging to the latter series whereas they belong to the former.

The Chipping Norton Limestone is to be traced *via* Stow on the Wold and Martin's Hill, Oddington, into the Chipping Norton District. Here it is separable into two portions—a lower (Hook Norton Beds) and an upper. The limestones of the lower portion are sandy, brown, and—in the railway-cutting near Hook Norton—contain plant-remains abundantly. Traced eastward they are at some localities mostly brown sand, with subordinate layers of blue-hearted sandy limestone ('planking'); at others (Newbottle Spinney), mostly limestones. The upper portion, in the vicinity of Chipping Norton, is mainly oolitic limestone (with *Oppelia fusca*

(Quenstedt)) ; but in the railway cutting near Hook Norton beds of white sand make their appearance. In the vicinity of Swerford the beds are partly sandy limestone and partly white sand (Swerford Beds), and eastward pass into the Lower Estuarine White Sands of Southern Northamptonshire. Variability in the lithic structure of the Chipping Norton Limestone of the North Cotteswolds is therefore not to be wondered at. Beds with brown plant-remains, reminiscent of the Hook Norton Beds, are displayed in the Moreton Road cutting north of Stow on the Wold and were formerly in Stonehill Quarry—No. 2, Donnington. Chipping Norton Limestone, some of the constituent strata of which are curiously 'flinty,' is displayed in Coombehillhead Rookery Quarry, Naunton, but the writer has not detected it to the west of a line connecting Broadway and Notgrove Stations : in the first cutting west of Notgrove Station and in Lime Hill Wood Quarry, 2½ miles south-east of Winchcomb, the tough Upper Estuarine Clay rests directly on Clypeus Grit.

Local Details

The Chipping Norton Limestone may be said to enter the North Cotteswolds from the Chipping Norton District by way of Martin's Hill between Oddington and Stow on the Wold. There are several quarries on this hill, but only one—to the south-west of the old windmilll—is 'in work.' The beds are extraordinarily disturbed, and this combined with quarrying operations, makes it impossible to identify precisely the same section at two consecutive visits if they are separated by any considerable length of time.

Oddington Stone Quarry, Martin's Hill [1]

		Ft.	Ins.
Superficial Deposit	Reddish soil with small Northern Drift pebbles.		
	Limestones, hard, sparsely-oolitic, somewhat flaggy, brownish, shelly—*Ostrea* being the most abundant fossil	Several feet.	
Great Oolite	Rhynchonella-Terebratula-Isastraea-Bed.		
	Greenish-yellow, clayey, oolitic marl, at some places passing into almost a shell-bank, at others into a shingle. *Rhynchonella concinna* auctt., *Terebratula globata* auctt. (*Stiphrothyris sp. nov.*), *Isastraea limitata* (Lamouroux), *Chlamys vagans* (J. de C. Sowerby), *Exogyra sp. nov.*, *Ostrea sp.*, *Serpula sp.*, etc. Some of the pebbles have oysters and polyzoa attached to them : 1 ft. to 1 ft. 6 ins.	1	3
	Limestones, brownish, oolitic ; *Ostrea* and shell-fragments : about ...	5	0

[1] Richardson, L., 'The Inferior Oolite and Contiguous Deposits of the Chipping Norton District, Oxfordshire,' *Proc. Cotteswold Nat. F.C.*, vol. xvii, pt. 2, 1911, p. 231.

		Ft.	Ins.
Upper Estuarine Clay (? trace of Neaeran Beds remanié)	Dirty-green, chocolate, and yellow and brown clay, with pebbles of dense brown limestone and reddish-brown sand at the base. Some of the pebbles are in process of being converted into rotten white carbonate of lime; lignite: up to	1	4
Chipping Norton Limestone.	Limestones, brownish, oolitic with oysters in places and brownish lignite. Thickness not ascertainable	6	0
Roundhill Clay	Clay, blackish, tough	0	6
Clypeus Grit	Limestone, rubbly, coarsely-oolitic to pisolitic, with *Terebratula globata* auctt., *Grammatodon hirsonensis* (d'Arch.), *Clypeus ploti* Klein, etc. At the top, in places, is a finer-grained brown oolite-bed, in which specimens of *Perna* are extremely abundant along with a large *Camptonectes*: seen about	4	0

Chipping Norton Limestone is exposed to a depth of about 12 ft. in a quarry north of Quar House, to the right of the road from Stow on the Wold to the station, where it is worked mainly for burning for lime.

H. B. Woodward noted '. . . in a road-cutting, and in a quarry to the west of Stow,'[1] on the road to Lower Swell:—

		Ft.	Ins.
'Inferior Oolite (Ragstones)	[Chipping Norton Limestone] Flaggy oolitic limestone, and hard brown obscurely oolitic limestones (resembling the Chipping Norton Limestone)	8	0
	[Clypeus Grit] Rubbly oolite with *Clypeus Ploti*.'		

It is usually difficult in the vicinity of Stow to determine whether the limestone in an exposure is Chipping Norton Limestone or Great Oolite.

Proceeding northwards from Stow on the Wold along the Fosse Way or 'Moreton Road,' old quarries will be observed on the right just beyond the turning to Broadwell. A fault traverses them: in 1904 Chipping Norton Limestone could be seen let down against typical Clypeus Grit. On the left, west, side of the road is exposed Chipping Norton Limestone consisting of yellowish, oolitic, flaggy limestone with abundant pebbles of oolite (the product of pene-contemporaneous erosion)—seen 5 ft., resting on hard fine-textured, crystalline limestone—seen 3 ft. (also Chipping Norton Limestone).

The sequence to be made out in quarries and a road-cutting a little further to the north is given on p. 73. It will suffice here to state that from the Chipping Norton Limestone worked in the quarry in the field west of the Fosse Way road-cutting the quarrymen frequently obtain dinosaurian remains: Dr. F. B. A. Welch obtained here a vertebra,[2] which was identified by Mr. A. T. Hopwood of the British Museum (Natural History) as a lumbar vertebra of *Megalosaurus*. The lower portion of the Chipping Norton Limestone exposed in the road-cutting is similar to the lower portion of that subdivision in the Chipping Norton district to distinguish which the writer has used the name 'Hook Norton Beds.'

[1] 'The Jurassic Rocks of Britain' (*Mem. Geol. Surv.*), vol. iv, 1894, p. 144.

[2] Presented to the Geological Survey Museum, Reg. No. 37523.

At Stonehill Quarry—No. 2, near Donnington, Chipping Norton Limestone (probably the Hook Norton Beds portion) is seen succeeded non-sequentially by Taynton Stone (see p. 113).

At ½-mile E. by S. of Banks Fee Farm is Newpark Quarry, of which H. B. Woodward stated that[1] it "showed from 18 to 20 feet of pale shelly limestones with *Ostrea*, the beds were more or less oolitic, and minutely current-bedded. The higher layers were fissile like the slaty beds of Hyatt's Pits, and these are overlaid by a bed of hard brown oolitic limestone, and by about 3 feet of rubbly oolitic limestones with *Ostrea*."

Newpark Quarry, Longborough

		Ft.	Ins.
Chipping Norton Limestone	Limestone, light brown-grey, locally whitish; coarsely oolitic in places; occasional carbonaceous specks; *Belemnopsis sp.* (fragment), *Steneosaurus sp.* (fragments of a mandible[2]), *Teleosaurus subulidens* Phillips (scute of)[3]: seen	20	0
	Yellow sandy marl, crowded with little black pebble-like bodies (see below)	0	0-8
	Limestone, yellowish, incipiently 'nodular': seen	4	0

This quarry is of considerable interest: for (1) the thickness of the Chipping Norton Limestone; (2) the marl with 'little black pebble-like bodies'; and (3) the number of crocodilian remains obtained—mostly by the quarrymen.

One of the little black pebble-like bodies has been analysed by L. G. Annis at Bristol University and found to contain:—'chiefly (1) manganese in form of psilomelane (bulk of powder); (2) a quantity of iron in form of limonite; (3) calcium carbonate; (4) a fair quantity of a phosphate, probably calcium phosphate; and (5) a small insoluble residue of siliceous material.'

A road runs along the east side of the quarry southwards into the Condicote road. In the low east bank of this road is seen first Chipping Norton Limestone, and then, below, Clypeus Grit.

About three miles N.N.W. of Newpark Quarry and about 1 mile westward of Bourton on the Hill, is a quarry 'in work' in which about 12 ft. of Chipping Norton Limestone is exposed (see p. 69).

Chipping Norton Limestone floors extensive tracts in the 'heart of the North Cotteswolds.' It is well exposed in quarries:—(1) 260 yds. S.W. by W. of Bourton Hill Farm, where it is conspicuously current-bedded; (2) 440 yds. S. of Smallthorns, where it contains locally pebbles of oolite and black specks; and (3) 500 yds. S.W. by W. of Snowshill Hill, where about 20 ft. of rock is exposed—also with black specks. About 180 yds. down the depression to the W. by S. from the first quarry, in the vicinity of the 700-ft. contour line, there is much rubble on the field of typical Clypeus Grit.

In the tract between Horn's Leazor and the Buckle Street, Chipping Norton Limestone tilestones were formerly very extensively worked—the name of the pits being Hyatt's or Hyates Pits (see p. 144). There is a small quarry in the Limestone on the eastern edge of this ground a little to the N.W. by N. of Horn's Leazor.

[1] 'The Jurassic Rocks of Britain' (*Mem. Geol. Surv.*), vol. iv, 1894, p. 143.

[2] Obtained by Dr. F. B. A. Welch and presented by him to the Geological Survey Museum (Reg. Nos. 37520, 37521, 37522). Identified by Mr. A. T. Hopwood.

[3] Identified by Sir Arthur Smith Woodward.

Near the pond alongside the Buckle Street in the dip five-sixths of a mile S.E by E. of Snowshill is an old quarry in Chipping Norton Limestone. The beds are very 'tiley': some are a mass of oyster-fragments and locally contain numerous very small pebbles. Faults greatly affect the rocks of this district; but to the south, at the plantation the limestone comes on and is part of the northern margin of a very extensive spread.

The Chipping Norton Limestone tilestones have been worked at the now plantation-covered Upper and Lower Slatepits and underlie the Ling Ground. The rock extends eastwards to the dry-bottomed Horn's Leazor valley.

At the crossing of the Buckle Street and Stanway-Horn's Leazor road are two quarries: one—presumably the eastern one—is S. S. Buckman's 'Section xi.—Cross-roads ¾-mile south of Hyates Pits, and about ½-mile from Scarborough Barn.'[1] Buckman's record is:—

'Clay, from evidence of infillings.

	Ft.
Fissile stone with small *Ostreae*: about	14

NOTE.—I presume that the fissile stone was formerly worked for roofing tiles. This seems to be the same bed as that at Hyates Pits.'

Buckman, while admitting that the sequence of Upper Snowshill Clay, Tilestone, 'Lower' Snowshill Clay, and Harford Sands was 'only very incompletely observed,' thought that the Tilestone of this neighbourhood was the equivalent of the rock of *concavi* hemera below the Clypeus Grit at his 'Section x.—Bourton Clump,' and therefore named the clay above the 'fissile stone' here at the cross-roads 'Upper Snowshill Clay.' The clay, however, is Upper Estuarine Clay and the 'fissile stone' Chipping Norton Limestone.

About 150 yds. from the cross-roads down the Stanway road and close to the north side of the road in Heaver Plantation, is a quarry 'in work' for road-metal. This quarry shows the following section:—

		Ft.
Chipping Norton Limestone	Limestones—the top beds 'tiley,' but the main mass of the beds not so, but a good road-metal containing black specks and brown plant-remains (*cf.* Hook Norton Beds): seen	10

On the upper portion of the field, lower down to the west, is much rubble of typical Clypeus Grit (see p. 61).

The greater part of the tract east of the Buckle Street and contained by the Cutsdean parish (and county) boundary from the cross roads ½-mile northward of Cutsdean Hill eastward to the Horn's Leazor valley and down that valley to Hinchwick; the road thence south-west by southwards to near Rook Pool; and the Guiting road thence westward to the Buckle Street, is floored with Chipping Norton Limestone which gives rise to a sandy soil.

Chipping Norton Limestone is seen in old quarries at:—(1) 350 yds. N.N.W. of Hinchwick Hill Barn; (2) five-twelfths of a mile W. by S. of Hinchwick Hill Barn, near which are old Chipping Norton Limestone tilestone workings (below the level of which Clypeus Grit can be traced westward along the valley side); (3) Cutsdean Lodge; (4) a little less than ¼-mile N.E. of Botany Barn where there are old tilestone workings (below the level of which occurs rubble of Clypeus Grit); (5) at Guitinghill Farm—white 'sandy'

[1] *Quart. Journ. Geol. Soc.*, vol. lvii, 1901, p. 136.

limestones, flaggy more than ' tiley ' ; (6) at ½-mile N. of Guitinghill Farm, where the top-layer seen is fissile stone practically made up of shell-fragments and contains minute pebbles of oolite ; (7) slightly more than ½-mile N.W. by N. of the farm (rock ' tiley ') ; (8) 365 yds. N. of the farm ; (9) seven-twelfths of a mile S.W. by W. (where there is heavy clay soil—residual Upper Estuarine Clay) ; (10) 660 yds. S.W. by S. of the farm by the side of the by-road from Lower Barn near its junction with the Stow-Guiting road.

In the plantation on the south side of the Guiting road a little before the crossing of the Buckle Street is reached from the east is Bevan's Quarry.

Bevan's Quarry, Temple Guiting

		Ft.
Chipping Norton Limestone	Limestones, on the whole thickly-bedded, but inclined to weather rubbly, with partings of sand and marl. The top-portion in particular is inclined to be sandy weathering down locally into a brown-yellow sand. Carbonaceous matter locally in partings near the bottom : seen ...	12

This is S. S. Buckman's ' Section xii.—Guiting Hill.'[1] He queried the upper 8 ft. as Tilestone (of *concavi* hemera) and identified the beds below with his Lower Snowshill Clay. He said :—' About 4½ miles south-south-east the Harford cuttings show some 5 feet of a freestone characterized by small *Ostreae*, over-lying Harford Sands. I presume this is the same bed [as the upper 8 ft. at Bevan's Quarry] in an attenuated condition, and without any distinct deposits of Snowshill Clay.'

The rocks seen in Bevan's Quarry are Chipping Norton Limestone ; the Tilestone in the Harford Cutting rock of *concavi* date contemporaneous with that so dated at The Holt Quarry (p. 67), ' Roadstone Quarry ' west of Bourton on the Hill (p. 69), Five Mile Drive Quarry (p. 67), and Sezincote Hill (p. 72).

Proceeding southwards along the Buckle Street, Chipping Norton Limestone tilestone is seen in several openings. About ¼-mile E. of Bembro' in Devonport Wood, is a quarry ' in work.'

Devonport Wood Quarry

	(In southern part of quarry) :—	Ft.
Chipping Norton Limestone	Tip of tilestones from old workings ...	6
	Limestones, massive-looking, wedge-bedded ; split into rough tilestones ; *Tancredia planata* Morris & Lycett [Regd. No. 3943]. The rock varies in structure and colour : there are three principal varieties—white-grey, fine-textured ; brown, with white fragments of oysters and black specks ; and blue : seen	6

The distribution of the Chipping Norton Limestone in the ' Condicote District ' is shown on Dr. F. B. A. Welch's map which is reproduced on p. 116. The principal section in this district is in the Guitinghill Quarry, 1 mile westward of Condicote.[2]

[1] *Quart. Journ. Geol. Soc.*, vol. lvii, 1901, p. 137.

[2] Richardson, L., ' Excursion to the North Cotteswolds : Hinchwick Valley and Spring Hill,' *Proc. Cotteswold Nat. F.C.*, vol. xxiii, pt. 1 for 1927 (1928), pp. 8. 9, and pl. 1, fig. 2.

Guitinghill Quarry—No. 1, near Condicote

		Ft.	Ins.
Upper Estuarine Clay	In one portion of the quarry, let in at the top, is residue of green and black clay. [*Non-sequence*: Neaeran Beds absent]		
Chipping Norton Limestone	1. 'Node Beds.' Limestones, sandy, where freshly-quarried conspicuously blue-grey. Somewhat 'thinly-flaggy' and in the median position consisting of layers of sandy limestone with very hard calcareous 'node-like swellings' and shaly marl; *Lima cardiiformis* Morris & Lycett, *Ostrea sp.*, *Rhynchonella concinna* auctt.	5	0
	2″. Sand, pale brown and grey. Locally this sand passes into fissile sandy 'slate'	0	8
	2‴. Limestones, fairly massive-bedded, but locally slightly rubbly with pebbles. Near the base is an interrupted layer and pebbles of a whitish lithographic stone (*cf.* bed 2 (basal portion) Fenwick's Quarry, p. 95) ...	1	7
	2*a*. Oyster-Bed. Indurated marl crowded with oysters of the *Ostrea sowerbyi*-type and locally pebbles; *Strophodus magnus* Agassiz (tooth), *Trigonia pullus* J. de C. Sowerby, *Rhynchonella concinna* auctt., echinoid spines. Passes in one place into a hard oolitic limestone and in the south part of the quarry into a soft, white-grey, locally yellow-streaked marl with oysters: 1 to 15 ins.	1	0
	3. Limestones, grey-white, massive bedded, but locally weathering, flaggy, with well-rolled pebbles of oolite distributed throughout the beds; *Ostrea* cf. *sowerbyi* Lycett (common), *Camptonectes lens* (J. Sow)., [Z. 3939, 3940], *Lima cardiiformis* Morris & Lycett [Z. 3936-3938], *Mytilus sublaevis* J. de C. Sow. [Z. 3941], *Rhynchonella concinna* auctt: seen	6	0

A little to the northward of this quarry, at the turning for Condicote, is an old quarry.

A.—GUITINGHILL QUARRY, 1 MILE W. BY N. OF CONDICOTE CHURCH. CHIPPING NORTON LIMESTONE.

B.—COSCOMBE QUARRY, S.E. OF STUMPS CROSS, 1½ MILES S.E. BY S. OF STANWAY CHURCH. MASSIVE 'YELLOW GUITING STONE.'

Guitinghill Quarry—No. 2.

	Ft.	Ins.
Dark coloured soil	1	4
Yellowish clayey marl, with a little rubble of whitish and slightly oolitic limestone in places near the top; *Ataphrus labadyei* (d' Archiac), *Cerithium sp.* (smooth species), *Nerinaea dufrenoyi* d'Archiac, *N.* cf. *voltzi* Desl., *Pseudomelania* cf. *hamptonensis* (M. & L.). *Modiola lonsdalei* M. & L., *Ostrea sowerbyi* Lycett, *Trigonia pullus* J. de C. Sow. (as figured by Lycett, Monogr. Brit. Fossil Trigoniae, pl. xxxiv, fig. 9), *Rhynchonella concinna* auctt., *Terebratula maxillata* J. de C. Sow., *Cyathopora pratti* Edwards & Haime [Reg. No. 37952], *Isastraea limitata* (Michelin) [Reg. No. 37953, 37954], and *Microsolena excelsa* Edwards & Haime [Reg. No. 37955] ...	1	11
Limestone, grey, flaggy, somewhat arenaceous; *Ostrea* cf. *acuminata* J. Sowerby: seen	6	0

The gastropods were identified by W. H. Hudleston: the corals by R. F Tomes.

In 1903 the writer described the beds displayed in this quarry as ' Great Oolite.'[1] At that time Chipping Norton Limestone had not been identified in the North Cotteswolds. He is not quite satisfied with the suggestion but would suggest tentatively that the ' yellowish clayey marl . . . ' is a variation of bed 2*a* of Guitinghill Quarry—No. 1.

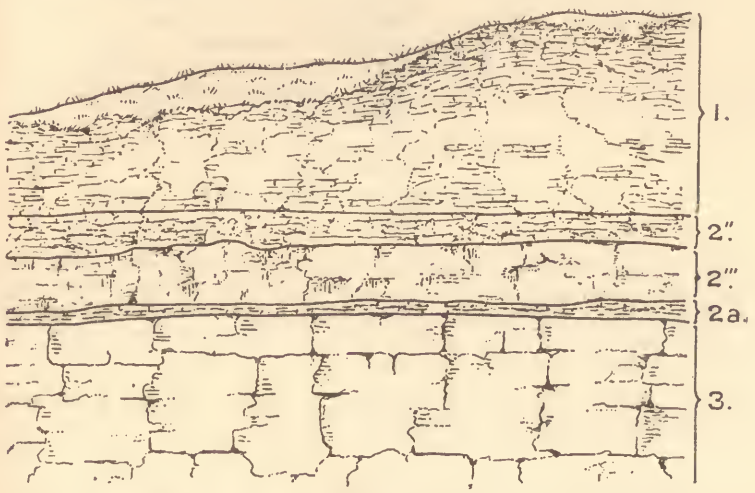

FIG. 3.—*Guitinghill Quarry, 1 mile W. by N. of Condicote Church. Chipping Norton Limestone.*

About 220 yds. N.N.E., on the west side of the road to Hinchwick, near the bench-mark 718, is an old quarry, at the northern end of which, just below the turf, is seen Upper Estuarine Clay resting on Chipping Norton Limestone. In the eastern corner of the field to the north is a shallow quarry in the Chipping Norton Limestone—in places rock, but mostly yellow and white loose ' sand ' analogous with that seen in the sand-hole between Condicote

[1] Note on a section of Great Oolite Beds at Condicote, near Stow on the Wold,' *Geol. Mag.*, 1903, p. 404.

and Flagstone. In the second field to the north-east is a quarry in typical Chipping Norton Limestone containing oysters and brown plant-remains. Lower down over a portion of the northern extremity of the field west of Hinchwick, and east of the road, is rubble of typical Clypeus Grit. Up this hill-side Chipping Norton Limestone is seen at intervals between 650 and 718 ft. but doubtless the rocks are affected by faults.

At ⅔-mile N.W. by N., and again at ⅔-mile W. of Kinetonhill Farm, certain of the Chipping Norton Limestone strata are ' slates ' or tilestones difficult to distinguish from the Stonesfield ' Slates ' of the Eyford District.

At ½-mile S. of Condicote is Bolton's Ground Quarry in which Chipping Norton Limestone is quarried beneath a covering of Neaeran Beds (locally) and Upper Estuarine Clay (see p. 99).

A quarry ¼-mile S.E. by E. of Fox Farm exhibits Chipping Norton Limestone, oolitic, locally very shelly (principally fragments of oysters), weathering exceptionally ' tiley.'

Quarry at ⅓-mile S.E. by E. of Fox Farm

		Ft.	Ins.
Chipping Norton Limestone	1. Limestone, brown, finely oolitic ; occasional fragments of oysters : seen	2	0
	1*a*. ' Marl,' yellowish, numerous oysters—some of *O. acuminata*-, others of *O. sowerbyi*-type ...	0	4
	2. Ragstone. Limestone, hard, shelly, with numerous oysters ; *Lima cardiiformis* Morris & Lycett	1	9
	2*a*. Locally calcite and limonite (see below) : 0 to 4 ins.	0	2
	3. Limestone, brown-grey, oolitic : seen	4	0

With reference to the ' calcite and limonite,' probably the calcite crystals formed first, and then certain, by a metasomatic change, were replaced by chalybite (iron carbonate). The change would account for diminution in volume of the replaced crystals, their porosity, and also allow for the oxidation of the chalybite to limonite.[1]

In an opening in a field about ⅓-mile south-east of Condicote, and the same distance N.W. by W. of Flagstone, is seen :—

		Ft.
Chipping Norton Limestone	Oolite, fine-grained, with hard portions —principally at the top. In the main the rock weathers down into a yellow oolite ' sand.' In certain weathered faces it is to be observed from the manner of weathering that the deposit is conspicuously false-bedded : seen...	4

About half-way between Condicote and Upper Swell are Flagstone Cottages.

[1] Double, I. S., ' Specimens of Limonite from the Oolite of the North Cotteswolds,' *Proc. Cotteswold Nat. F.C.*, vol. xxii, pt. 2, for 1925 (1926), p. 161.

Flagstone Quarry

		Ft.	Ins.
Chipping Norton Limestone	1. Limestone, brown, obscurely oolitic, weathering somewhat flaggy; occasional oysters: seen	2	0
	1*a*. Marl, very local: average ...	0	1
	2. RAGSTONE or RAG. Limestone, shelly, with numerous oysters and *Lima cardiiformis* Morris & Lycett...	3	6
	2*a*. Marl, brown and yellow; local: 0 to 3 ins.	0	3
	2. Limestones, brown, oolitic, with a tendency locally to decement to sand: seen	12	0

The limestones below the Ragstone have yielded useful flagstones in the past (hence the name of the locality), which were worked in a 'mine' that went under the road. This 'mine' has had its entrance blocked: a similar 'mine' is seen in the western part of the quarry—near the old limekiln.

About ½-mile along the Guiting road from Upper Swell, on the right hand side just before the turning to Flagstone and Condicote a road-side face shows:—

Chipping Norton Limestone	Limestones, mostly in massive beds. In the rock just above the 'incipiently nodular limestone' little pebbles of oolite are abundant.
	Limestone, incipiently nodular (*cf.* Newpark Quarry section, p. 89).

Not quite 1 mile E.N.E. of Swell Buildings in Lower Swell parish, is a quarry 'in work' for stone for building walls which may be called 'Fenwick's Quarry.'

Fenwick's Quarry, Lower Swell

	Tip from old workings.	Ft.	Ins.
Chipping Norton Limestone	1. Limestone, brown, sandy, with numerous borings filled with consolidated material: seen ...	1	6
	2. RAGSTONE. Limestone, hard, shelly—principally fragments of oysters; *Lima cardiiformis* Morris & Lycett. Contains hard 'node-like swellings' (*cf.* Guitinghill Quarry, p. 92), is pebbly, and, in the basal portion contains small lumps of a whitish, lithographic stone ...	2	4
	(Rests slightly unevenly on bed below)		
	2*a*. Locally, brown marly deposit; 0 to 6 ins.	0	3
	3. Limestones, brown-grey, oolitic, with a ferruginous surface: seen	12	0

The quarrymen said that 'bones' had been obtained from bed 3.

About ¼-mile west of Lower Swell, on the south side of the road to Swell Hill Farm, etc., and just outside Standles Coppice, the Chipping Norton Limestone is quarried for road-stone, and from it Dr. F. B. A. Welch obtained a specimen of *Oppelia fusca* (Quenstedt).

At ½-mile W.S.W. of Fenwick's Quarry the Ragstone is seen packed with specimens of oysters of the *O. sowerbyi*-type.

In the second field west of Swell Hill Farm, Chipping Norton Limestone is exposed that weathers very fissile on exposure and produces tilestones much resembling Stonesfield Slates.

Lower down the hill, about ¼-mile before reaching Swell Wold Cottages, a road-side quarry shows :—

Quarry near Swell Wold Cottages

		Ft.	Ins.
Chipping Norton Limestone	2. Limestone, brown, shelly ; packed with specimens of *Ostreae* of an *O. sowerbyi*-type ; *Lima cardiiformis* Morris & Lycett : seen ...	5	0
	2*a*. Marl, brown, yellow and greenish, stony in places ; numerous oysters ; *Amberleya sp.*, *Trigonia pullus* J. de C. Sowerby, *Rhynchonella concinna* auctt., *Terebratula maxillata* J. de C. Sow. (same form as from Guitinghill Quarry—No. 2, p. 93) : about	2	0
	3. Limestones, massive, fine-grained, sandy, obscurely oolitic ; split into rough tilestones : seen ...	4	0

About 200 yds. to the S.W by W. is a quarry in the same beds :

Swell Wold Cottages Quarry

		Ft.	Ins.
Chipping Norton Limestone	2. Limestone ; packed with oysters, seen	3	0
	2*a*. Marl, brown and yellow : 2 to 5 ins.	0	3
	3. Limestone, very fissile : seen ...	5	0

Comparing these two sections, the bed numbered 2 in each is clearly contemporaneous. So is that numbered 2*a*, and this is useful knowledge for it demonstrates how greatly a contemporaneous deposit in the upper portion of the Chipping Norton Limestone varies in this neighbourhood.

At 1¼-miles S.W. by W. of Lower Swell is a cutting on the Cheltenham-Stow road west of Hollow Barn.

Hollow Barn Road Cutting, Eyford

		Ft.	Ins.
Chipping Norton Limestone	Limestone, brown, in the main sparsely oolitic, locally flaggy ; *Ostrea sp.*, *Chlamys vagans* (J. de C. Sow) : seen	7	0
	(About 20 yds. westward towards Eyford).		
Ditto (base)	Limestone.		
	[*Slight non-sequence* : Roundhill Clay absent]		
Clypeus Grit	Limestone, hard, rubbly, somewhat marly, scattered iron-grains and irregular ferruginous veins ; *Terebratula globata* auctt., *Anabacia complanata* (Defrance), *Clypeus ploti* Klein—all rare : seen ...	4	0

At ½-mile E.N.E. along the Stow road is a quarry ' in work ' for road stone in Granny's Bank Coppice.

Granny's Bank Coppice Quarry

		Ft.	Ins.
Upper Estuarine Clay	Locally, heavy clayey soil	0-2	0
	[Not now preserved—owing to quarrying operations—but seen in 1904[1] and 1907[2] :—		
	Clay, tough dark greenish-brown, with fragments of oysters and pieces of a peculiar brown limestone-bed, crowded with gastropods. From this limestone-bed were collected *Pseudomelania sp.* (not unlike '*Eulima*' *laevigata* or '*E.*' *communis* of M. & L.), *Pseudomelania sp.* [near to '*Eulima*' *laevigata* M. & L.; *cf.* also *P. astonensis* (Hudleston)], apical whorls of *Amberleya sp.* and ? *Alaria, Cerithium* (of the *C. muricatum*-group), '*Phasianella*' cf. *conica* M. & L., *Natica* aff. *bajociensis* d'Orbigny, ? *Nerinaea sp., Tancredia,* and radioles of an echinoid.		
	Below the clay in one place was seen a remarkable deposit of sand. At the top it gradually passed into the clay, but near the base it contained many small quartz pebbles and little black concretions of a limonitic material.]		
Chipping Norton Limestone	Limestone, thin-bedded, flaggy, with occasional well-rounded small pebbles of oolite : seen	1	0
	Pebble-like accumulation : 2 to 4 ins.	0	3
	Limestone, in places grey, fine-grained, and sparsely oolitic, and in others, yellow, crystalline ; coarsely oolite, weathering flaggy and into small bits; *Ostrea sp., Chlamys vagans* (J. de C. Sow.)	8	0
	Limestone yellowish and incipiently ' nodular ' (*cf.* lowest beds at Newpark Quarry, p. 89) : seen ...	1	0

The clay and sand at the top of the section were local and much disturbed, but it will be evident that they represent the Upper Estuarine Clay and sand such as have been noted in the quarry near Roundhill Farm (p. 98), and, by E. A. Walford, in the Roundhill railway-cutting (p. 112) respectively. The Gastropod Limestone may be a Neaeran Bed.

The gastropods from it was identified by the late W. H. Hudleston, who wrote :—' There are a considerable number of species here, but their condition

[1] *Proc. Geol. Assoc.*, vol. xviii, pt. 8, 1904, p. 405.

[2] Richardson, L., ' Excursion to Bourton-on-the-Water . . . ', *Proc. Cotteswold Nat. F.C.*, vol. xvi, pt. 1, 1907, p. 24 (' Quarry near Lower Swell ').

is such that even generic determinations are difficult. The most abundant shell is a narrow form of *Pseudomelania*, not unlike the "*Eulima*" *laevigata*, or "*E.*" *communis* of Morris & Lycett.'

The echinoid-radioles are near, if not identical with, the radiole of an unknown species figured by T. Wright in his 'Monograph on the British Fossil Echinodermata from the Oolitic Formations,' (*Palaeontographical Society*), pl. xvii, fig. 10, from the Stonesfield Slate of Eyford. If anything the ribs are a little more prominent in the Granny's Bank specimens.

Three miles S. by 62°W. of Granny's Bank Quarry the Chipping Norton Limestone is displayed beneath a covering of Upper Estuarine Clay in a quarry close to Roundhill Farm.

Roundhill Farm Quarry, Naunton

		Ft.	Ins.
Fullers' Earth—Basal portion	Upper Estuarine Clay. Clay, heavy, chocolate-coloured: somewhat slipped forward at the south end of the quarry: seen	2	0
	Grey-green clay (*cf.* bed 5 at Sharp's Hill[1]), weathering to a whitish-green 'marl'; with, at the base	1	3
	Clay, blackish (*cf.* bed 6 at Sharp's Hill), mixed with some green clay: in places one regular band; in others spreads out	0	4
	[*Non-sequence*: Neaeran Beds absent]		
Chipping Norton Limestone	Brown marly layer, locally ferruginous, with locally very small oolite pebbles and oysters	0	4
	Limestone, obliquely-laminated, oolitic (especially in the upper portion). Where weathered, the obliquely-laminated rock yields rough tilestones: seen	5	0

At ¾-mile S.S.W. of the Roundhill Farm Quarry and S. of Combehillhead Rookery is a quarry, 'in work,' in the same subdivisions, but the lithic structure of the bulk of the Chipping Norton Limestone is a hard grey splintery limestone—an exceptional development.

Combehillhead Rookery Quarry, Naunton

		Ft.	Ins.
Fullers' Earth—Basal portion	Upper Estuarine Clay. Clay, heavy; brown, green and black: up to	3	0
	Clay, heavy, brown	0	6
? C. N. Limestone	Locally marl and stone weathering creamy white	1	0
Chipping Norton Limestone	Series of variable limestones with occasional shaly partings. Certain of the limestone bands, especially those towards the top, are very coarsely oolitic with shell-fragments; but the greater number are grey splintery limestones: seen	10	0

[1] 'The Inferior Oolite and Contiguous Deposits of the Chipping Norton District, Oxfordshire,' *Proc. Cotteswold Nat. F.C.*, vol. xvii, pt. 2, 1911, p. 207.

Neaeran Beds

The Viviparus Marl of the Neaeran Beds—which are so well developed in North Oxfordshire—is well displayed in Bolton's Ground Quarry, ½-mile to the south of Condicote. Indications of certain beds were once observed in Granny's Bank Coppice Quarry, Upper Slaughter parish ; and, may be, traces (remanié) are present at Martin's Hill, between Stow on the Wold and Oddington (p. 88).

Local Details

Bolton's Ground Quarry

		Ft.	Ins.
Upper Estuarine Clay	Clay, tough, dark brown (=bed 5*c* at Sharp's Hill Quarry[1]), black in places and more especially so at the base where it makes a fairly regular black deposit (=Bituminous Clay of Sharp's Hill) : up to	3	0
	Locally a seam of rich brown, ferruginous clay (*cf.* Sharp's Hill).		
	[*Slight non-sequence*]		
Neaeran Beds	Viviparus Marl. Marl, pale greenish-grey (see below), with—as a rule—white concretions (as at Sharp's Hill). Curiously-shaped, well-water-worn pebbles of oolite (probably derived Chipping Norton Limestone) are sparsely distributed throughout. *Cerithium* sp.[2], ? *Turbo sp.*[3], *Alectryonia* cf. *costata* (J. de C. Sowerby), *Lucina sp.* (very near to *L. despecta* Phillips), *Ostrea* aff. *sowerbyi* Morris & Lycett, *Isastraea explanata* (Michelin), & *Thamnastraea lycetti* Milne Edwards & Haime : up to ...	1	8
	[*Non-sequence* : Beds 7-20 of the Neaeran Beds of Sharp's Hill absent]		
Chipping Norton Limestone	Ferruginous rock weathering to a reddish brown deposit (*cf.* 20*a* at Sharp's Hill)	0	3
	Limestones, massive, locally weathering flaggy : seen	8	0

Note.—The ferruginous layer and overlying Viviparus Marl have been only very locally preserved. The overlying tough, heavy, Upper Estuarine Clay is more widely distributed and locally fills in hollows and crevices in the Chipping Norton Limestone where that rock has been markedly disturbed.[4]

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[1] Richardson, L., ' The Inferior Oolite and Contiguous Deposits of the Chipping Norton District, Oxfordshire.' *Proc. Cotteswold Nat. F.C.*, vol. xvii, pt. 2, 1911, p. 207.

[2] Either the upper whorls of a spire of the so-called *Cerithium muricatum* Sowerby or of *C. vetustum* (Morris & Lycett), ' Monogr. Mollusca Great Oolite ' (*Palaeontographical Society*), 1850, pl. xv, fig. 7, p. 114.

[3] This may be a species of *Turbo*. See *Turbo ' paludinoides '* Hudleston, ' Monogr. Inf. Ool. Gasteropoda ' (*Palaeontographical Society*), pl. xxix, fig. 2, p. 355.

[4] Pictured, *Proc. Cotteswold Nat. F.C.*, vol. xxii, pt. 2 for 1925 (1926), pl. viii, fig 2.

Upper Estuarine Clay

This clay is very distinctive—very ' tough,' and green, brown, chocolate and black. The black clay generally constitutes a layer at the bottom. The deposit is a westerly extension of the basal Upper Estuarine Clays that have so wide a distribution in North Oxfordshire and Southern Northamptonshire—the black clay being correlative with bed 6 of Sharp's Hill, near Hook Norton, and the green clay with bed 5*c*.[1]

In the North Cotteswolds traces of the Upper Estuarine Clay occur at many places : the Clay has been observed above the Chipping Norton Limestone at Oddington Stone Quarry, Martin's Hill (p. 88) ; in the Roundhill Railway Cutting (obscured) (p. 112) ; Combehillhead Rookery Quarry (well displayed) (p. 98) ; quarry near Roundhill Farm (ditto) (p. 98) ; Bolton's Ground Quarry (ditto) (p. 99) ; at the cross-roads ½-mile from Scarborough Barn (p. 90) ; and, resting on the Clypeus Grit, at Lime Hill Wood Quarry (p. 54), and in the first cutting west of Notgrove (p 75).

The clay seen in places at the top of the quarry in the Chipping Norton Limestone at the cross-roads near Scarborough was named the ' Upper Snowshill Clay ' by S. S. Buckman, who thought that the rock below was Tilestone of *concavi* date.[2]

Fullers' Earth (Local)

The Upper Estuarine Clay, until the writer's investigations, had not been identified in the North Cotteswolds, but was included in the local Fullers' Earth. This local Fullers' Earth, above the Upper Estuarine Clay, consists of grey clay locally yellow at the top. The two colours show distinctly in the mainly grass-covered northern side of the Roundhill Railway Cutting, where the total thickness of the local Fullers' Earth is about 23 ft. 4 ins. The upper portion of the Fullers' Earth is well displayed in the Hampen Railway Cutting (p. 106).

The approximate distribution of the Fullers' Earth in the Condicote District, so far as it can be determined, is shown on Dr. F. B. A. Welch's map which is reproduced on p. 116. In 1921, R. S. Arkell, of Fox Farm, near Condicote, excavated and bored in the hollow about ½-mile W.N.W. of the farm. ' When dug . . . [the excavation] was 15 feet deep. . . . It was all clay and marl and we did not get through it although we bored a considerable distance after digging.' (R. S. Arkell, *in litt.* 3.5.1922.)

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[1] Richardson, L., ' The Inferior Oolite and Contiguous Deposits of the Chipping Norton District, Oxfordshire,' *Proc. Cotteswold Nat. F.C.*, vol. xvii, pt. 2, 1911, p. 207.

[2] ' Bajocian and Contiguous Deposits in the North Cotteswolds : The Main Hill-Mass,' *Quart. Journ. Geol. Soc.*, vol. lvii, 1901, p. 136.

The clay dug out is grey Fullers' Earth clay and, as seen by that in the heap, is full of selenite crystals. Green Upper Estuarine Clay is seen in shallow ponds at (1) 110 yds. to the south-east, and (2) at 500 yds. to the north-west.

The Fullers' Earth (less the Upper Estuarine Clay) probably attenuated toward the line of the Moreton anticlinal axis; but in any case subsequent movements along that axis locally caused its present-time absence.

CHAPTER V

GREAT OOLITE

The Great Oolite extends northward for some distance into the present district from its main wide outcrop to the south. The beds have been much displaced by faults, and these, together with the valleys excavated by the streams, have resulted in the production of dissected and outlying masses situate at various altitudes.

The best section for ascertaining the characters of, and determining the subdivisions that may be made in, the Great Oolite of this district, is that in the railway-cutting at Hampen between Andoversford and Notgrove Stations. As H. B. Woodward recorded[1], the main natural stratigraphical subdivisions, in descending order, are :

White Limestone
Marly Beds
Taynton Stone
Stonesfield Slate Series

Stonesfield Slate Series

For the present the *Rhynchonella*-Bed (see pp. 105, 106, etc.) is taken as the top-bed of this Series.

Oysters of *Ostrea acuminata*-outline range from the Clypeus Grit to the *Rhynchonella*-Bed (inclusive), which latter may be regarded also as the top-bed of the Vesulian. The *Ostrea acuminata*-Limestones that occur immediately below the *Rhynchonella*-Bed are packed with specimens of the characteristic oyster and if an observer familiar, for example, with the geology of the Nailsworth district were to find pieces of the limestones loose he would doubtless say that they had come from amid the main mass of Fullers' Earth. The Stonesfield State Series with the included ' slate-bed ' would appear to be merely a special development in deposits which in certain other districts are commonly called ' Fullers' Earth.' A prominent local fact in support of placing the upper limit of the Vesulian as indicated is that previous to the formation of the Taynton Stone there was flexing of the deposited Stonesfield Slate beds, local erosion, and non-sequential deposition of Taynton Stone.

The distribution of the constituent deposits of the Stonesfield Slate Series will be seen by a study of the records of sections that follow. It is such as to demonstrate that the beds were laid down in an area unstable on account of the proximity of the Moreton

[1] ' The Jurassic Rocks of Britain ' (*Mem. Geol. Surv.*), vol. iv, 1894, pp. 292, 293.

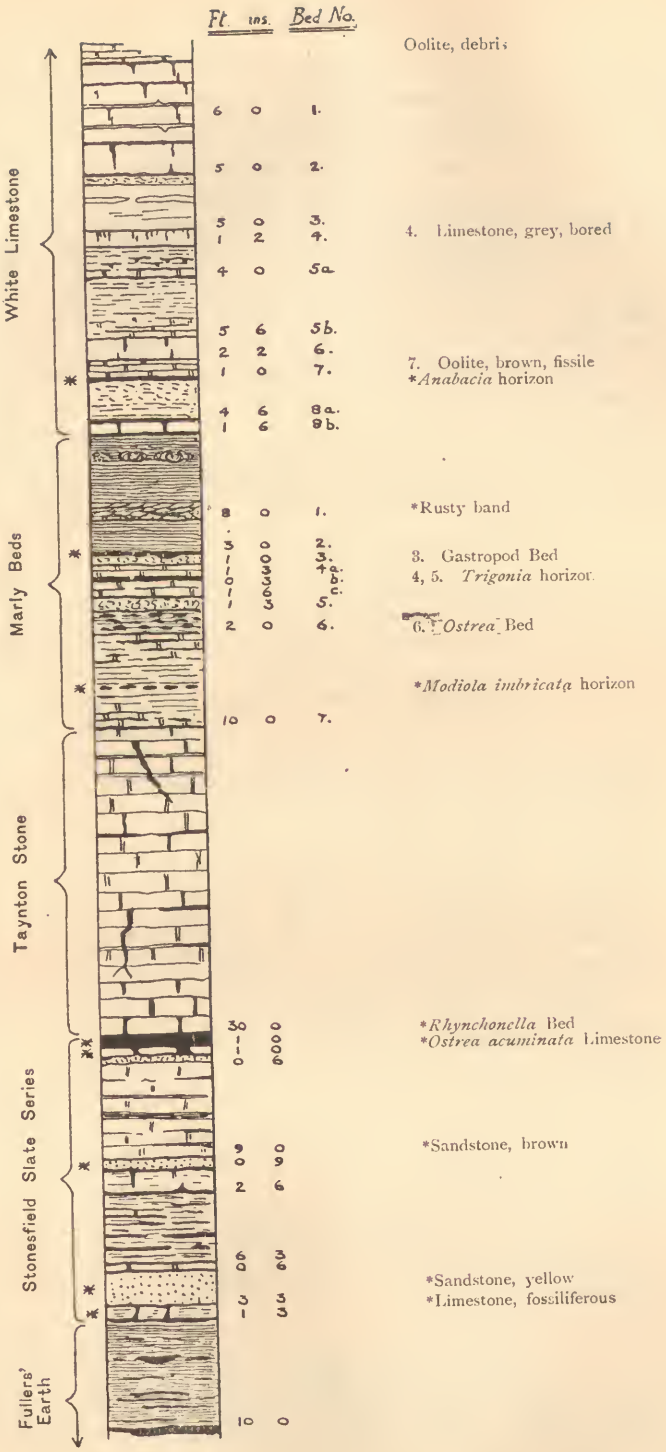

FIG. 4.—*Section of Great Oolite Series, Hampen Railway Cutting.*

Anticline. Also, the manner in which certain of the beds in the Eyford Hill area (p. 115) were riddled by 'worms' suggests that the limit of the area of deposition was not far distant.

It is of interest to note that Stonesfield Slate has not been worked in the district under consideration eastward of a line joining Kinetonhill Farm, Swell Wold Cottages, Wagborough Bush, and Aston Blank, nor eastward beyond until the Stonesfield district is reached. So far as the present district is concerned the reason is that, if originally deposited, it was upraised in the vicinity of the Moreton Anticline and removed, and it may be suggested that the 'slate-bed' of the Stonesfield district comes in a synclinal area to the east of the Moreton Anticline.

Some particulars of the Stonesfield or, as it is now known in this district, 'Cotswold' Slate from a fossil-content standpoint are given on p. 114,[1] and from a commercial standpoint on p. 144.

Local Details

Such details as are now obtainable in the Hampen Railway Cutting in respect of the Stonesfield Slate Series are given in the following record, but, unfortunately certain of the constituent deposits are only imperfectly displayed.

Hampen Railway Cutting

		Ft.	Ins.	Ft.	Ins.
White Limestone	Oolite, brownish (debris)				
	1. 'White Limestones; rubbly beds with Gastropods, *Ostrea*, *Terebratula maxillata*, (smooth forms) [*Natica*, *Lucina*, *Clypeus* (fragment)], and Corals	6	0'		
	2. Limestone, creamy-white, with scattered yellow ooliths; *Natica*, *Nerinaea*, *Lima cardiiformis* Morris & Lycett, *Lucina* (common), *Isastraea sp.*	5	0		
	3. Alternations of pale grey marly limestones and somewhat fissile marls; in top portion —*Amberleya sp. indet.*, *Terebratula*	5	0		
	4. Limestone, grey, sparsely oolitic; upper part bored	1	2		
	5*a*. Limestones, rubbly, harder in the lower portion; *Lucina*	4	0		
	5*b*. Marly beds; limestones subordinate except at base	5	6		
	6. Limestone, similar to 2; *Lucina*	2	2		
	7. Oolite, brown, fissile	1	0		
	Yellowish marl with numerous specimens of *Anabacia complanata* (Defrance)				
	8*a*. Limestone, similar to 2, but rubbly; *Nerinaea*, *Lucina*, *Isastraea sp.*	4	6		
	8*b*. Limestone, similar to 2	1	6		
				35	10

[1] The fine series of fossils from the 'slate-bed' of the Eyford District collected by the Rev. E. Witts of (Upper) Slaughter, which was mentioned in 1857 by Hull in 'The Geology of the Country around Cheltenham' (*Mem. Geol. Surv.*), p. 55 (footnote), is still in the possession of the Witts family at Upper Slaughter Manor.

		Ft.	Ins.	Ft.	Ins.
Marly Beds	1. Marls, oolitic, bluish-grey, yellow at the top, with two stone bands— *a*. Limestone, pale blue-grey, with dark shell fragments. *b*. Limestone, flaggy ; lignite. Occasional specimens of *Ostrea sowerbyi* M. & L.	8	0		
	2. Marls, ditto, with—at the base—a rusty band	3	0		
	3. Gastropod Bed. Greenish-grey, earthy and oolitic limestone ; *Natica, Pseudomelania, Modiola imbricata*	1	0		
	passing down into				
	4*a*. Limestone, harder ; *Lucina, Trigonia pullus* J. de C. Sow.	1	3		
	4*b*. Marl ; *Echinobrissus*	0	3		
	4*c*. Limestone	1	6		
	5. Yellow and grey, rubbly oolitic marl ; *Protocardia, Trigonia pullus* J. de C. Sow. ...	1	3		
	6. Ostrea Bed. Bluish-grey, shaly marl, *Ostrea sowerbyi* M. & L., large and abundant	2	0		
	7. Marls, bluish grey, with occasional bands of oolitic limestone and fine-grained sandy limestone with curious tracks of animals like those of the Forest Marble. (*Modiola imbricata* horizon at 7 ft. down) Marls, similar, passing down into limestone	10	0		
				28	3
Taynton Stone	' Pale fine-grained oolite, false-bedded, with shelly and marly layers here and there, coarser oolite in places, and occasionally fissile beds (=Taynton Stone) : about ...	30	0 '		
				30	0
Stonesfield Slate Series	Rhynchonella Bed. Yellowish marl ; *Rhynchonella* (*Kallirhynchia obtusa* S. Buckman, *Terebratula globata* auctt. (*Stiphrothyris sp. nov.*)	1	0		
	Ostrea acuminata Limestones. Limestone, full of specimens of *Ostrea acuminata* J. Sow.: up to	1	0		
	Sevenhampton Marl. Yellowish marl ...	0	6		
	2. Limestones, mostly fine-grained, compact, with occasional white ooliths, locally fissile ; but with shelly coarse oolite at the top and bottom (3)	9	0		
	4. Sandstone, brown : has weathered to resemble at a distance ' yellowish marl'	0	9		
	5. Limestone, hard, fine-grained, compact, with occasional white ooliths, but locally coarsely oolitic ; *Rhynchonella sp., Ostrea sp.*, etc. ...	2	6		
	6. Shales, bluish, paper—, with fissile, sandy, layers	6	3		
	7. *a*. Limestone, sandy, fissile : up to	0	6		
	b. Sand, yellow	3	3		
	8. Limestone, hard, blue-hearted, slightly sandy, with 'claystone' inclusions ; *Chlamys vagans* (J. de C. Sow), *Gervilla ovata* (J. de C. Sow.), *Placunopsis socialis* (M & L.), *Ostrea acuminata* J. Sow.	1	3		
				26	0

		Ft.	Ins.
Fullers' Earth	Shales, bluish, paper—, with layers of hard, pale grey marl and occasional thin layers of fissile, fine-grained sandy stone : seen ...	10	0

Stonesfield ' Slates,' or, to be correct, ' stone-tiles,' were for a long time extensively worked on Sevenhampton Common ; but the old workings were given up about 1854 as all the ' slates ' that could be conveniently got had been drawn, and the increasing thickness of the overburden prevented continuance of the industry being a business proposition.

Murchison,[1] H. E. Strickland and J. Buckman,[2] the Rev. P. B. Brodie,[3] and Brodie and Buckman,[4] gave some particulars of these old pits ; and H. B. Woodward recorded that in 1887 ' slates ' were being worked ' about a third of a mile south-west of Whitall [White Hall] Farm.'[5]

No pits are now open : the last ' in work ' in the locality was situated in the second field west of the road near Nash Barn close to the wall of the Common, $\frac{7}{8}$-mile W. by N. of Sevenhampton Church. In 1904,[6] and again in 1920 (with some additional fossil-records),[7] the writer gave particulars of this section ; but the rock therein described as ' Stonesfield Slate ' is the top of the Ragstone, the true ' Slate ' occurring at some 14 ft. lower down. The following amended record is therefore given :—

Sevenhampton Common Quarry[8]

	Ft.	Ins.
Rhynchonella Bed. Clay, bluish-grey and yellowish ; *Nautilus sp.* (cast.) *Natica alta* J. Buckman, *Nerinaea gracilis* Lycett, *N. dufrenoyi* d'Archiac, *Pseudomelania lineata* (J. Sow.), *Ptygmatis striata* (J. Buckman), *Alectryonia costata* (J. de C. Sow.), *Ostrea acuminata* J. Sow., *O. acumimata* but with an *O. subrugulosa*-ornamentation, *O. sowerbyi* Morris & Lycett, *Rhynchonella concinna* auctt.,[9] *Terebratula globata* auctt. (*Stiphrothyris sp. nov.*), *Berenicea* cf. *verrucosa* (Milne Edwards) *Acrosalenia spinosa* Agassiz, *Clypeus* aff. *mulleri* Wright, *Anabacia complanata* (Defrance), *Isastraea limitata* (Lamouroux), and *Serpula sp.* : seen 1 ft. 3 ins. but a thickness of 6 ft. (without apparently the top being seen) recorded at a section in the vicinity by Strickland and Buckman	1	3
Ostrea acuminata Limestones.[10] (*a*) Limestone, full of specimens of *Ostrea acuminata* J. Sow. ; *Nerinaea* sp. : 2 to 4 ins.	0	3
(*b*) Clay ; full of *Ostrea acuminata* J. Sow : 2 to 3 ins. ...	0	2
(*c*) Limestone similar to (*a*) : 2 to 3 ins.	0	2

[1] Outline of the Geology of the Neighbourhood of Cheltenham,' 1834, p. 8.
[2] *Ibid*, new ed., 1844, by H. E. Strickland and J. Buckman, pp. 17-21.
[3] ' Fossil Insects,' 1845, pp. 40-42.
[4] ' On the Stonesfield Slate of the Cotteswold Hills,' *Quart. Journ. Geol. Soc.*, vol. i, 1845, pp. 222, 223.
[5] ' Jurassic Rocks of Britain ' (*Mem. Geol. Surv.*), vol. iv, 1894, p. 295.
[6] ' A Handbook to the Geology of Cheltenham . . . ', 1904, p. 163.
[7] ' Excursion to the Andoversford District,' *Proc. Cotteswold Nat. F.C.*, vol. xx, pt. 3, 1920, pp. 176, 177.
[8] It will be convenient for this section to be known by this name.
[9] Forms of *Rhynchonella concinna* auctt. have been named by S. S. Buckman in ' The Brachiopoda of the Namyau Beds of Northern Shan States, Burma,' *Palaeontologica Indica*, n.s., vol. iii, Mem. 2, 1917, p. 223, and pl. xv, figs. 10-17.
[10] Strickland and Buckman observed ('Geology of Cheltenham,' 1844, p. 18) associated with these limestones ' A thin seam of indurated whitish clay, composed of the smaller arms of *Apiocrinites* . . . [10 in.].' The *Apiocrinites* were probably *Millericrinus pratti* Gray, and the bed in which they occurred of the same age as Walford's ' brown shelly marl ' in the second cutting east of Notgrove (see p. 110).

	Ft.	Ins.
SEVENHAMPTON MARL. Marl, sandy, indurated in places; *Strophodus sp.* (tooth), *Lima cardiiformis* (J. Sow.), *Pinna ampla* J. Sow., *Ostrea acuminata* J. Sow.: 4 ft. 6 ins. to 6 ft. 2 ins., but a thickness of 8 ft. recorded at a section in the vicinity by Strickland and Buckman	5	4
RAGSTONE BEDS. According to Strickland and Buckman	14	0
STONESFIELD SLATE. Limestone, grey and greenish-grey, sandy. The middle portion is a very hard blue-hearted rock slightly oolitic, and yields the 'slates.' *Perisphinctes gracilis* (J. Buckman) (Holotype), *Hybodus grossiconus* Ag., *Belemnopsis bessinus* (d'Orbigny), *Nuculana waltoni* (Morris & Lycett), *Placunopsis socialis* (M. & L.), *Trigonia impressa* J. de C. Sow., *Pollicipes ooliticus* J. Buckman, *Astropecten cotteswoldiae* J. Buckman, and *Carpolithus diospyriformis* (Sternberg) and other plant-remains	4	6
CLAY, greenish-yellow		

The thickness of the *Rhynchonella*-Bed clay recorded by Strickland and Buckman is surprising; but need not be doubted. The *Ostrea acuminata* Limestones and Sevenhampton Marl are well and distinctly developed here.

About 2 miles to the east of Sevenhampton Common, or 1 mile due east of Sevenhampton Church, is a disused quarry[1]:—

Quarry near Sevenhampton	Ft.	Ins.
RHYNCHONELLA BED. Clay, yellowish; *Rhynchonella concinna* auctt., *Terebratula globata* auctt. (*Stiphrothyris sp. nov.*): seen	1	0
OSTREA ACUMINATA LIMESTONES. (*a.*) and (*c*) Limestone, in two layers full of specimens of *Ostrea acuminata* J. Sow.	1	0
SEVENHAMPTON MARL. Marl clayey in some places, sandy in others; *Ostrea acuminata* J. Sow., *Placunopsis socialis* (M. & L.), *Pleuromya sp.*	3	0
4. Limestone, greyish-white, and locally oolitic; weathers in places into three or four beds	1	6
5. Marl, whitish, oolitic, stone in places, clay at top and base. That at the base is dark-blue and full of shell-fragments	0	6
6. Limestone in two layers. The upper band is hard, brownish-grey, and non-oolitic; it is bored in places; *Ostrea sp.*, *Trigonia sp.* (3 ins.). The lower band is somewhat rubbly with marl in places; *Rhynchonella concinna* auctt., *Terebratula sp.* (5 ins.)	0	8
7. Marl, brownish and greenish-brown; argillaceous stone in places	0	4
8. Limestone, brownish, somewhat fissile; 7 to 11 ins. ...	0	9
9. Marl, light-brown, indurated in places, laminated ...	0	2
10. Limestone, greyish and brownish, fissile	0	4
11. Marl, parting: 1 to 3 ins.	0	2
12. Limestone, greyish, oolitic; few fossils; certain beds fissile: seen	7	0

Beds 4 to 7 inclusive may be contemporaneous with the 'Marly Beds' of the sections on Salperton Downs, etc.

At ¾-mile to the north-eastward is a quarry, not now 'in work,' near Whitehill Farm.

[1] See Richardson, L., 'A Handbook to the Geology of Cheltenham . . .', 1904, p. 166.

Quarry near Whitehill Farm, Hawling

	Ft.	Ins.
Limestone, grey, flaggy; apparently unfossiliferous: seen	1	0
Rubbly, yellow-hearted, shelly limestone; 0 to 2 ins. ...	0	1
RHYNCHONELLA BED. Clay, bluish-grey and yellowish; *Chlamys vagans* (J. C. de Sow.), *Cypricardia rostrata* Sow. var. *truncata* Morris, *Ostrea sp.*, *Pholadomya sp.*, *Rhynchonella concinna* auctt., *Anabacia complanata* (Defrance)	2	6
OSTREA ACUMINATA LIMESTONES. (*a*) Limestone, yellowish full of specimens of *Ostrea acuminata* J. Sow.	0	4
(*b*) Clay, brownish, and bluish-grey; *Ostrea acuminata* J. Sow.	0	2
(*c*) Limestone similar to (*a*)	0	2
SEVENHAMPTON MARL. Marl, clayey in some places, sandy in others; *Ostrea sp.*	1	1
6. Limestone, whitish, oolitic, weathers flaggy; shell fragments	6	0
7. Limestone, pinkish, shelly	0	4
8. Clay, greenish, with a thin stone band: 0 to 4 ins. ...	0	2
9. Limestone, grey, brown ooliths, shelly in places ...	0	6
10. Clay, greenish	0	2
11. Limestone, grey, brown ooliths; splits up into thin, somewhat sandy layers in the upper part; *Ostrea sp.*: 8 to 10 ins.	0	9
12. Limestone, grey, almost non-oolitic; *Ostrea acuminata* J. Sow.	0	11
13. Limestone, grey	1	7
14. Limestone, grey, passing down into an extremely shelly stone, with a few brown ooliths; *Ostrea sp.* ...	2	0
15. Limestone, hard, grey, very shelly, a few brown ooliths	1	1
16. Limestone, hard, grey, brown ooliths, surface conspicuously ripple-marked; *Ostrea sp.*: seen ...	0	4

The *Rhynchonella*-Bed (seen about 8 ins.), *Ostrea acuminata* Limestones ((*a*) 3 ins.; (*b*) 3 ins.; and (*c*) 3 ins.), and Sevenhampton Marl (1 ft.), together with the subjacent Ragstone Beds, have been observed in a quarry at Roel Gate[1]; but the section is now mostly overgrown.

Stonesfield Slates have been somewhat extensively worked in the past on Salperton Downs—1¾-miles E. by S. of the 'Quarry near Sevenhampton.' In 1924 an old pit in the now-felled northern portion of the western of the two Downs Plantations was re-opened; but, owing to the thickness of the overburden, 'slate'-getting was not proceeded with here, and a pit was opened on the edge of the valley to the west. The sections displayed in these two pits when taken together give reliable information concerning the sequence from the Fullers' Earth to the Taynton Stone. A comparison of bed 2 in the two pits demonstrates the great difference in character of a sandy limestone where it has been protected from decalcification and where it has not: in the former case it is a hard bed; in the latter, mainly a loose sand—at Quarry No. 2, 'The Riddings.'

The Downs Quarry—No. 1[1], Salperton

	Ft.	Ins.
TAYNTON STONE. Oolite, shelly, obliquely-laminated, with, at the base,		
A very shelly layer containing *Lima cardiiformis* Morris & Lycett	3	0

[1] Richardson, L., 'A Handbook to the Geology of Cheltenham . . .', 1904, p. 164.

	Ft.	Ins.
RHYNCHONELLA BED. Clay, bluish grey and brown, but weathering to a light bluish-grey, brown-zoned marl; *Rhynchonella concinna* auctt., *Terebratula globata* auctt. (*Stiphrothyris sp. nov.*,) (rare), and oysters of *Ostrea acuminata*- and *O. sowerbyi*-groups ... ... [*Non-sequence*: *Ostrea acuminata* Limestones and Sevenhampton Marl absent. In the basal portion of the *Rhynchonella*-Bed is an impersistent layer of flat pebbles, rolled and bored, to which oysters and *Serpulae* are attached. The top-portion of the bed below is brown and scaly, and contains numerous specimens of the *Ostrea acuminata*-group].	1	0
MARLY BEDS. 1. Limestones, hard, grey, crystalline, parted by layers of marl	1	3
1*a*. Marl, dark and brown, clayey and shaly, with irregular layers of Limestone	0	9
2. Sandy limestone, brownish and fissile in the upper part, passing down into hard, grey, sandy limestone	2	4
3. OOLITIC MARL, shelly—decemented oolite	0	8
4. Sandy limestone, brown, fissile, passing down into hard, grey, sandy limestone.		
The Downs Quarry—No. 2[1]		
2. Sandy limestones, hard-grey,—generally disturbed; but in one place an undisturbed mass is seen with a thickness of...	1	0
3. OOLITIC MARL, shelly, and shelly oolitic limestone	0	6
4. Sandy limestone, dark grey, fissile, mostly decalcified to a loose sand (the local 'Riddings'); but locally passing down into a hard, grey, flaggy, sandy limestone	2	4
5. RAGSTONE. Limestone, hard, grey and brown, blue-hearted, crystalline; full of specimens of *Pseudomelania communis* (Morris & Lycett) [Regd. No. Z. 3935] seen mostly in section	1	3
6. GREEN CLAY: 0 to 3 ins.	0	1
7. PENDLE. (*a*) Sandstone, brown, fissile, passing down into the (*b*) SLATE BED (1 ft. thick) in which fossils are not specifically common but there are numerous individuals of *Gervillia ovata* (J. de C. Sow.), *Lima cardiiformis* Morris & Lycett	2	0
8. PLANKING. Limestone, similar to RAGSTONE; full of specimens of *Pseudomelania communis* (M. & L.) (seen mostly in section)	1	3
9. Sandy limestone—at the top brown and shaly; below, grey. Surface undulating and waterworn. Oysters of the *Ostrea acuminata*-group common in the top-layer	1	3
10. CLAY, greenish and yellowish-brown, in irregular layers alternating with those of argillaceous and sandy stone: seen	1	3

[1] Within the area of the now-felled northern portion of the plantation.

An interesting feature about this section is that it exhibits strata—the Planking and Ragstone—below and above the Pendle which are crowded with specimens of *Pseudomelania communis* (M. & L.), which, even when in walls are readily recognised.

The Stonesfield Slate Series, in part or whole, is incised by a number of the cuttings on the Banbury and Cheltenham Railway, but several of the smaller sections are much overgrown.

In the Hampen Hill Cutting the whole of the Series is displayed with the Fullers' Earth below and the Taynton Stone, etc., above (see p. 105).

In the cutting north-west of Salperton there is still a fair section of the whole Series (exhibiting a sequence similar to that at Salperton Downs) with the Fullers' Earth below and 12 ft. of Taynton Stone above.[1]

In the first cutting east of Notgrove Station—east of the second fault—traces of Chipping Norton Limestone may be observed, but the succeeding Fullers' Earth and basal portion of the Stonesfield Slate Series is now grass-covered.

The second cutting east of Notgrove is now mostly overgrown, but it showed —according to H. B. Woodward[2]—(at the eastern end) the top of the Fullers' Earth, Stonesfield Slate Series and base of the Taynton Stone. This is probably the cutting in which E. A. Walford[3] observed between the Stonesfield Slate Series and the Taynton Stone his ' . . . crinoid bed [which] is a brown shelly marl, containing in the middle a thin band of oysters with rolled and bored stones. Included is a layer of limestone of about an inch in thickness, made up of crinoidal remains . . . I have picked from washings of the layer shells of *Cypris* and foraminifera of the following genera :—*Marginulina, Cristellaria, Lagena, Dentalina* and *Rotalia* . . . '

The crinoids P. H. Carpenter recognised as *Millericrinus pratti* (Gray)[4]

R. F. Tomes[5] obtained specimens of *Cladophyllia babeana* Milne Edwards & Haime, *Thamnastraea mammosa* M. Edw. & Haime, and *Microsolena regularis* M. Edw. & Haime (which were, however, not numerous) from a bed resting directly on the Stonesfield Slate (Series) ' in the railway-cutting at Aylworth.' Probably this was the railway-cutting and Tomes's coral-bed Walford's ' brown shelly marl,' which—it should have been mentioned—Walford gave as 1 ft. 1 in. thick.

The information given by Walford and Tomes concerning this ' marl ' or ' coral bed ' indicates that it represents the *Ostrea acuminata* Limestones (? in part worked up and converted into pebbles) and *Rhynchonella*-Bed of Sevenhampton Common (p. 106).

Three miles eastward of Salperton Downs, in a field adjoining the south side of the ' Bourton road ' or Stanborough Lane, is a quarry, ' in work ' for road-stone on the site of old ' slate ' pits.

Hull said :—' In the neighbourhood of Aston Blank the lower beds [of the Stonesfield Slate Series] yield good slates and flagstones, but the higher beds become oolitic.'[6]

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[1] ' Jurassic Rocks of Britain ' (*Mem. Geol. Surv.*), vol. iv, 1894, pp. 293, 294.

[2] *Idem*, pp. 131, 294.

[3] ' On some Crinoidal and other Beds in the Great Oolite of Gloucestershire and their probable equivalent in North Oxfordshire,' *Proc. Warwickshire Nat. and Arch. F.C.*, 1882, pp. 25, 26.

[4] ' On some new or little-known Jurassic Crinoids,' *Quart. Journ. Geol. Soc.*, vol. xxxviii, 1882, p. 38.

[5] ' On the Fossil Madreporaria of the Great Oolite of the Counties of Gloucester and Oxford,' *Quart. Journ. Geol. Soc.*, vol. xxxix, 1883, pp. 171, 173, 182, 190, 191.

[6] ' The Geology of the Country around Cheltenham ' (*Mem. Geol. Surv.*), 1857, p. 55.

Stanborough Lane Quarry

	Ft.	Ins.
Thick overburden of spoil from old ' slate ' pits.		
4. Sandy limestone, fissile, locally weathering to a loose brown and yellowish sand (*cf.* ' Riddings ' of Salperton Downs Quarry—No. 2), but locally passing down into a hard, blue, flaggy, sandy limestone : seen ...	2	0
5. Ragstone. Limestone, grey, with specimens of *Pseudomelania communis* (M. & L.), with a considerable admixture of green clay especially in cavities at and near the base : 6 ins. to 15 ins.	1	3
6. Green Clay, very local, usually having a sandy limestone on its horizon	0	10
7. Pendle. (*a*) Sandstone, calcareous, brown, fissile (locally a loose sand) passing down into (*b*) Slate Bed ; *Belemnopsis sp., Nerinaea sp., Gervillia ovata* (J. de C. Sow.), *Placunopsis socialis* (M. & L.), *Tancredia sp., Trigonia impressa* J. de C. Sow., etc. ... ... [? *Non-sequence* : no evidence for beds 8 (Planking) and 9 of Salperton Downs]	2	0
10. Clay, greenish-yellow, in irregular layers alternating with those of argillaceous and sandy stone : seen ...	0	6

In a separate opening, but within the eastern extremity of the old pit, is seen this section :—

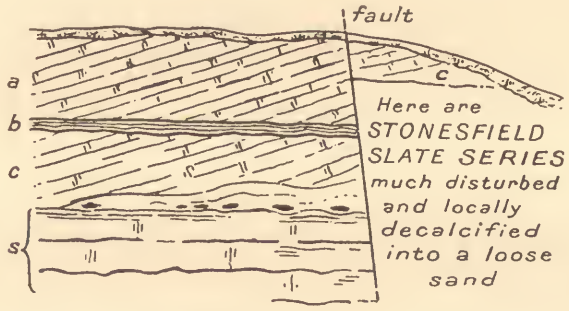

Fig. 5.—*Section of Taynton Stone and Stonesfield Slate Series*

Taynton Stone.—	Ft.	Ins.
a. Oolite, coarse, obliquely-laminated : seen	2	2
b. Marl, yellow, with a brown layer in the median portion	0	4
c. Oolite, coarse, obliquely-laminated, and, in the lower part current-bedded. In this current-bedded portion are crushed rhynchonellids apparently of the same species as those observed in similar rock at Stonehill Quarry—No. 2, Donnington (see p. 113). Locally in the basement layer are pieces of subangular rock derived from the subjacent bed ... ... [*Non-sequence*]	1	6
Stonesfield Slate Series (lower portion).—		
Sandy limestones, brown, and fissile in places at the top, but mostly hard : the surface of one of the beds is conspicuously ripple-marked : seen	1	8

The Taynton Stone is to be seen in quarries: (disused) by the roadway, from the Bourton road, to Upper Harford Farm; ('in work') ¼-mile N.N.W. of Folly Farm; (disused) some 300 yds. eastward of Ralph's Barn. It is evident from the Stanborough Lane Quarry section that the higher beds of the Stonesfield Slate Series have been removed by a pre-Taynton Stone erosion.

At $\frac{5}{6}$-mile to the N.E by N. the erosion effected the removal of all the Stonesfield Slate Series beds as is shown by the section in the Roundhill railway-cutting. The record of this section given below is a composite one as regards authorship for now only the beds in the neighbourhood of the junction of the Fullers' Earth and Taynton Stone are satisfactorily exposed.

The section first received attention at the hands of E. A. Walford[1] who said of the beds between the Clypeus Grit and the Fullers' Earth 'These appear to be the representatives of beds [Chipping Norton Limestone] which I have shown to attain no inconsiderable development eastwards.'[2]

In his record Walford gave 'Red sand' as occurring below the 'course of waterworn pebbles': it is comparable with a deposit once seen by the writer at Granny's Bank Coppice Quarry (see p. 97).

In 1887 S. S. Buckman gave a more detailed account of the section[3]—especially the beds below the Fuller's Earth; but was unable to indicate a deposit elsewhere comparable with the 'sandy beds' (the Chipping Norton Limestone).

In 1906 Walford repeated his 1883 record, gave a list of the fossils from the Chipping Norton Limestone, and a list of ostracoda got from washings from the nodules of the 'course of waterworn pebbles.'[4] The ostracoda (11 new species) were described by T. Rupert Jones and C. D. Sherborn.[5]

Roundhill Railway Cutting

	Ft.	Ins.
TAYNTON STONE. Oolite, somewhat massive bedded: seen about	8	0
[*Non-sequence*]		
FULLERS' EARTH. 10 clay, greenish, yellow-streaked, with layers of marl and stone	0	5
Limestone, impure, with a tendency to become sandy and fissile in the topmost portion	0	6
Marl, yellowish	1	6
Marl, bluish	1	2
Marl, yellowish, with layers of clay, and a number of limestone bands, some of which are sandy and fissile, micaceous, with annelid tracks, and one about the middle, full of specimens of *Ostrea sp.*: about...	3	9
Clay, very tough, yellowish: about	1	0
Clay, bluish, marly: about	15	0
CHIPPING NORTON LIMESTONE. Course of waterworn pebbles of hard brown oolitic limestone with oysters, *Serpulae*, and Polyzoa attached.		

[1] 'On the Relation of the so-called "Northampton Sand" of North Oxon to the Clypeus Grit,' *Quart. Journ. Geol. Soc.*, vol. xxxix, 1883, p. 225.

[2] *Idem*, p. 237.

[3] *Proc. Cotteswold Nat. F.C.*, vol. ix, pt. 2, 1887, pp. 123, 124, 128.

[4] 'On some New Oolite Strata in North Oxfordshire,' 1906 (8vo Buckingham), pp. 6, 7.

[5] 'On some Ostracoda from the Fuller's Earth Oolite and Bradford Clay,' *Proc. Bath N. H. and Antiq. Field Club*, vol. vi, 1888, p. 249.

	Ft.	Ins.
According to E. A. Walford :—		
' Red sand, derived from the decomposition of [the top portion of] bed 4 [*i.e.*, the underlying rock]	1	2 '
According to S. S. Buckman :—		
' Rough oolitic debris, with somewhat rubbly oolitic stone	0	4
Reddish sandy oolitic debris	0	4
Same, but rather harder and more compacted, like stone ...	0	11
Light brown limestone, with darker patches, *Waldheimia ornithocephala* ? crushed	0	3
Rubbly marl	0	6
Light brown sandy stone	0	10
Brown oolitic paste, decomposed	0	9
Bands of brown sandy limestones, with softer partings ...	3	9
[Roundhill Clay.] Bluish brown clay at the bottom, with quantities of broken shells, *Aviculae* ? changing into a browner marl at the top	1	6
[Clypeus Grit.] Hard light brown, slightly oolitic stone ...	0	9
Yellow rubbly rock	3	6
Harder ditto, *Terebratula globata, Clypeus ploti* [seen] ...	1	6 '

Five miles north-eastward of the Roundhill Railway Cutting, or 1¼-mile N. by W. of Stow on the Wold, an old quarry shows :—

Stonehill Quarry—No. 2

(East side of quarry)	Ft.	Ins.
Taynton Stone. Limestone, grey-white, oolitic : seen ...	1	0
Marl, yellow, and flaky limestone ; occasional oysters and worm-burrow infillings	0	10
Limestone, grey-white, oolitic ; crushed specimens of *Rhynchonella sp.*	2	0
[*Non-sequence* : Neaeran Beds—Stonefield Slate Series (inclusive) absent]		
Chipping Norton Limestone. Limestone, grey-brown, sandy.		
(West side of quarry)		
Limestone, grey-brown, sandy ; brown plant-remains, *Ostrea sp., Lima cardiiformis* Morris & Lycett : total thickness about	8	0
Limestone, in irregular layers with film-like partings of greenish-yellow marl : seen	1	0

The Chipping Norton Limestone, as is known from sections in the neighbourhood, rest on Clypeus Grit.

Proceeding westwards, away from the line of the Moreton anticlinal axis, the Stonesfield Slate is seen to come in again and to be well-developed in the ' Eyford District' —a district that embraces such well-known localities in the history of the ' Cotswold Slate ' industry as Kyneton (or Kineton) Thorns, Chalk Hill, Eyford Hill, and Summerhill above Naunton. It is on record that at Kyneton Thorns no less than 120,000 ' slates ' were made in one season.[1]

At the present time ' slates ' are being actively worked at Huntsman's Quarry, ½-mile N.N.E. of Summerhill, Naunton parish ; Eyford Hill, Eyford ; in a number of small pits amid the extensive old workings between these two localities ; and near New Buildings, Eyford parish, close to the west side of the Stow road between Harford Bridge and where it is crossed by the Buckle Street.

[1] Murchison, R. I., ' Geology of Cheltenham,' new ed., 1844, p. 22.

The district was well-known to the early local geologists as one in which the ' Slate Bed ' yielded many and exceptionally-interesting fossils.[1] The fossils are to be had mostly from the ' slatters ' who come across them when they are splitting and shaping the ' slates.' Those that may be met with include :— remains of pterodactyles (*Rhamphocephalus prestwichi* Seeley), dinosaurs (*Megalosaurus sp.*) ; crocodiles (*Steneosaurus brevidens* (Phillips), *Teleosaurus subulidens* Phillips) ; fish (*Lepidotus sp., Mesodon rugulosus* Agassiz, *Hybodus grossiconus* Agassiz, *Ischyodus emarginatus* Egerton, *Strophodus magnus* Agassiz, *S. tenuis* Agassiz) ; the ammonite *Perisphinctes gracilis* (J. Buckman); belemnites (*Belemnopsis aripistillum* (Lhwyd), *B. bessinus* (d'Orbigny)); gastropods ; lamellibranchs ; the cirripede *Pollicipes ooliticus* J. Buckman[2] ; insects ; the annelid *Pachynereis corrugatus* Etheridge[3]; insects ; the star-fish *Astropecten cotteswoldiae*[4] J. Buckman ; and plants.

Huntsman's Quarry, Naunton

	Ft.	Ins.
Limestone, grey, rather hard : seen	2	6
Marl, grey and yellow ; shell fragments—mostly of oysters ; one specimen of *Rhynchonella ? concinna* auctt.	0	6
Limestone, yellowish, sparsely oolitic ; *Lima cardiiformis* Morris & Lycett	2	9
' The ' Crop.' Oolite, grey, obliquely-laminated : makes ' Presents '	2	8
[? Rhynchonella Bed, and Ostrea Acuminata Limestones remanié]. Marl, brown, clayey, with oysters and a few pebbles bored by *Lithophagi* : 0 to 4 ins.	0	2
[? =Sevenhampton Marl] Marly limestone, crowded with oysters ; *Lima cardiiformis* M. & L., *Modiola sp.*, *Pholadomya solitaria* M. & L., *Pinna ampla* J. Sow., and occasional plant-remains, locally passing into a hard limestone ...	2	0
?1-5. Flagstones. Limestones, massive, flaggy, in the main blue hearted, but locally yellow and oolitic. Contain locally pebbles of oolite, and, in cavities in the lower part of the bottom stratum (5), green clay (*cf.* Ragstone of Stanborough Lane Quarry, p. 111)	6	6
6. Green Clay, locally sandy ; average thickness	0	2
7. Pendle. (*a*) Sandstone, hard, grey (weathering brown), rarely passing into a brown, irregularly-laminated fissile sandstone	2	8
(*b*) Limestone, hard, grey, sandy ... ... [*Non-sequence* : no evidence for the equivalent to the Planking]	1	6
9. Sandy limestone, hard, grey—at the top brown and shaly, containing flat marl pellets. Surface undulating and water-worn. *Placunopsis socialis* (Morris & Lycett) common in the top layer. Said to be a very hard bed and not worked.		

[1] See Murchison, *op. cit.* ; Brodie, P. B., ' Fossil Insects,' 1845, pp. 39-50 ; Brodie, P. B. and J. Buckman, ' On the Stonesfield Slate of the Cotteswold Hills,' *Quart. Journ. Geol. Soc.*, vol. i, 1845, p. 223.

[2] The type-specimen came from Eyford. Murchison, R. I., ' Geology of Cheltenham,' new ed., by H. E. Strickland and J. Buckman, 1844, p. 95, pl. 3, fig. 7.

[3] *Proc. Cotteswold Nat. F.C.*, vol. ix, pt. 1, 1887, p. 2.

[4] The type-specimen came from Eyford. Murchison, R. I., ' Geology of Cheltenham,' new ed., 1844, by H. E. Strickland and J. Buckman, 1844, p. 94, pl. 3, fig. 5. It was adopted as the ' Great Seal ' of the Cotteswold Naturalists' Field Club.

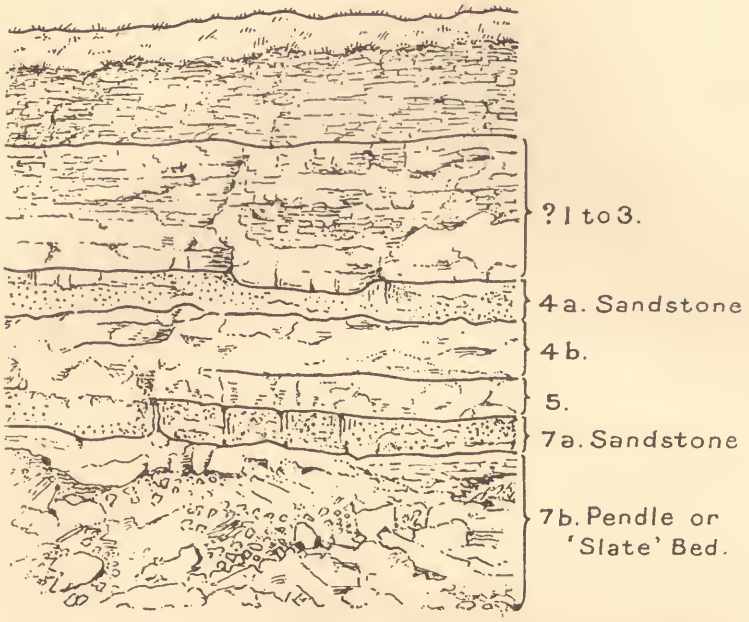

FIG. 6.—*The Cotswold Slate Co.'s Pit, Eyford Hill. Stonesfield Slate Series*

Cotswold Slate Pits, Eyford Hill

		Ft.	Ins.
	[?=THE CROP]. Presents : Limestones, oolitic, flaggy : seen up to	4	0
	Limestone, grey, sandy, somewhat fissile ... ... [? *Non-sequence*]	0	9
? 1 to 3.	RAGSTONES. Limestones, thin-bedded, blue-hearted. Riddled with borings	4	0
4.	PRESENTS. (*a*) Sandstone, brown and yellow, noticeably fissile	1	0
	(*b*) Sandstone and sandy stone mixed. Riddled with borings	1	6
5.	RAGSTONE. Limestone, sandy, ferruginous stainings. Riddled with borings	1	0
6.	GREEN CLAY : 0 to 1 in.	0	1
7.	PENDLE. (*a*) Sandstone, brown, noticeably fissile ...	1	0
	(*b*) Limestone, hard, grey, sandy, yields excellent 'slates' ... ... [? *Non-sequence*, for below the 'Slate' Bed is said to come]	2	0
? 10.	CLAY.		

Individual beds exposed in these quarries are not easy to correlate with those displayed in quarries near Hawling and on Salperton Downs. Bed 9 of Salperton Downs is identifiable in the Huntsman's Quarry, but, judging from the information given that clay immediately underlies the Pendle, it is absent from Eyford. The Planking apparently is absent from both quarries.

The Pendle between New Buildings and the Stow road, the writer was informed, locally becomes 'pot-lids' embedded in (Fullers' Earth) clay.

Above the Pendle in the Eyford District the Green Clay is fairly persistent: in a small pit just north of New Buildings it is thicker than usual—3 inches. The bottom layer of the Flagstones at the Huntsman's Quarry would appear to represent the Ragstone of Salperton Downs; and, judging by the pieces of limestone, crowded with specimens of *Pseudomelania communis* (Morris & Lycett), which are lying about near New Buildings it is typically developed there.

The outstanding feature of the Cotswold Slate Pits section is the excessive riddling by worms of beds ? 1 to 3, 4*b* and 5: the irregular lumps of sand-rock from these beds on the tips are penetrated in all directions with the consolidated infillings of the burrows. The extensive replacement of hard layers by friable sand-rock renders the Stonesfield Slate Series in the vicinity of Eyford Hill unproductive of road- or rough building-stone: generally, those working the 'slates' sell the hard stone for use on the by-roads. The Flagstones are suitable for crazy paving.

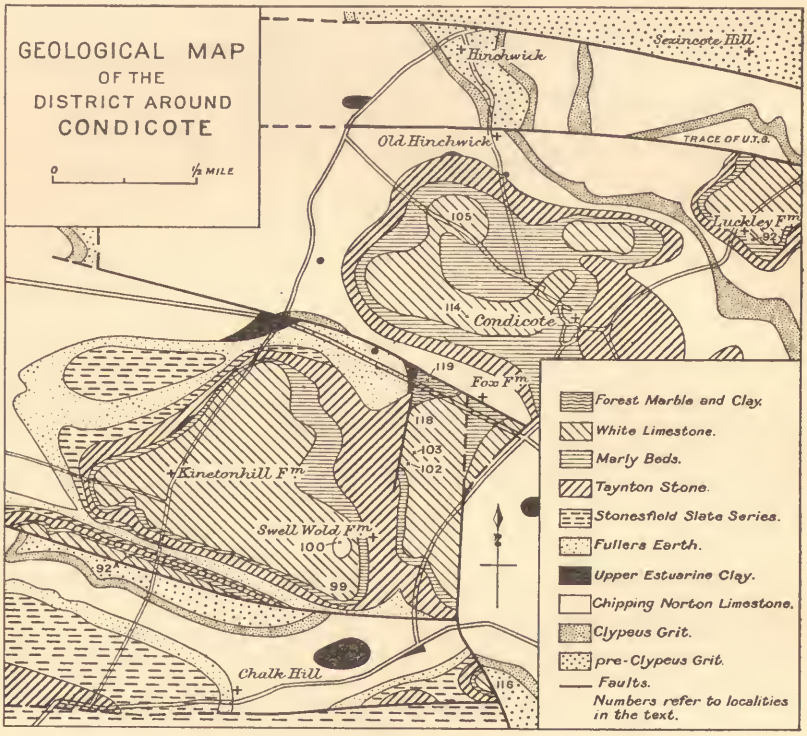

FIG. 7.

At ¾-mile east of Barton, Temple Guiting, in Upper Park Clump Quarry, about 15 ft. of limestone (from which a specimen of *Lima circularis* Morris & Lycett *non* Goldfuss was obtained [Z. 3942]), equivalent to the Ragstone Beds of Sevenhampton Common, are worked for road-metal.

The distribution of the Stonesfield Slate Series and Taynton Stone in the Condicote District, so far as it can be ascertained, is shown on Dr. Welch's map, which is reproduced above. For details concerning these two subdivisions in this District the reader is referred to Dr. Welch's paper.[1]

[1] 'On the Further Extension of the Great Oolite in the North Cotteswolds,' *Proc. Cotteswold Nat. F.C.*, vol. xxii, pt. 3 for 1926 (1927), pp. 219-238.

Taynton Stone

Oolite, which H. B. Woodward[1] regarded as ' =Tayton Stone,' is well exposed in the Hampen railway-cutting. Here its upper and lower limits are displayed and its total thickness is about 30 ft. (see p. 105). Locally, the oolite is replete with beautifully-preserved fossils (mostly lamellibranchs) of small size, and the general appearance of rock and fossils is reminiscent of the oolite of Minchinhampton near Stroud.

The significance of the bed that may be referred to as the ' Seven hampton *Rhynchonella*-Bed ' is not fully understood, so, for the present, it is considered best to regard it as the top-bed of the Stonesfield Slate Series.

When traced from the west, eastwards, in the direction of the Moreton anticlinal axis, it is found that the Taynton Stone rests on successively older rocks: at Stonehill Quarry—No. 2, it is seen resting on Chipping Norton Limestone. Probably it does the same in a north-eastward direction. Owing to lack of sections and the local failure of field-rubble due to many of the grounds being used for grazing, it is not possible to say with certainty what is the relationship of the Taynton Stone to the subjacent strata in the ' Condicote District ' ; but the relationship, so far as the facts permit it to be deduced, is indicated on the map on p. 116.

For the convenience of those who use this memoir ' in the field ' the sections of Taynton Stone are dealt with in the Local Details of the Stonesfield Slate Series.

Marly Beds

The Marly Beds are admirably displayed in the Hampen railway cutting. The top comes at the base of the piers of the bridge that carries the Salperton road (the Salt Way) across the cutting. The clayey top-portion throws out water from the base of the succeeding White Limestone. Oysters of the *Ostrea sowerbyi*-group occur throughout the beds, but in noteworthy number and of large size in the deposit that the writer has designated the '*Ostrea*-Bed ' (p. 105). Other facts worth noting in this section are :—(1) the *Modiola imbricata* horizon ; (2) the occurrence of *Echinobrissus* in bed 4*b* ; the abundant occurrence of *Trigonia pullus* J. de C. Sowerby in 4*a*, *c*, and 5 ; and (4) the distinctive appearance of 1*a*—a pale blue-grey non-oolitic limestone with dark shell-fragments.

In a disused quarry on the right-hand side of the road from Lower Swell to Eyford, and at some 300 yds. from the former village, is displayed a remarkable deposit, 6 ft. 10 ins. thick, almost wholly made up of the valves of oysters of the *Ostrea sowerbyi*-group. *Rhynchonella concinna* auctt. occurs very sparingly. At one time the writer held that the deposit came low down in the Great Oolite

[1] ' The Jurassic Rocks of Britain ' (*Mem. Geol. Surv.*), vol. iv, 1894, p. 293.

Series[1]; now he is of opinion that it belongs to the Marly Beds. The oysters are of large size—for *Ostrea sowerbyi*, and the deposit is a veritable oyster-bank.

The approximate distribution of the Marly Beds in the Condicote District is shown on the map on p. 116.

As far as can be determined they are the Marly Beds which (1) as a marly bed, replete with specimens of *Rhynchonella concinna* auctt., throws out the spring at Luckley; (2) as a similar bed, but full of oysters of an *Ostrea sowerbyi*-type, holds up the water in the pond, and is exposed in the pond-side, opposite (south of) Fox Farm, near Condicote; (3) as green and yellow marl, were excavated when a road-side ditch was deepened ¾-mile N.W. of Condicote (105 on the map, p. 116); (4) as brown clay on yellow marl, were excavated when a pond, ⅖-mile N.W. of Condicote, was deepened (93 on the map, p. 116); (5) hold up the water tapped by Betty Soul's Well, Condicote, and throw out a spring near by; and (6) throw out the spring which is caught in a tank from which it is raised by a hand-pump at the (Well) Cross, Condicote village.[2]

White Limestone

Beds belonging to the White Limestone subdivision of the Great Oolite are well displayed in the Hampen railway-cutting between Andoversford and Notgrove Stations. The section was described first in 1894 by H. B. Woodward,[3] and was re-examined in 1926 by the writer who found Woodward's information to be correct. In the record given on p. 104, however, the information is presented in different form from Woodward, and details are added.

The portion of the cutting in which the highest beds occur is smoothed down. Brownish oolite, however, is to be observed in the form of débris, and is similar to field-rubble found by Dr. Welch in the 'Condicote District'[4] that clearly occupies a higher stratigraphical position than the White Limestone proper. The particulars given of bed 1 are Woodward's, because this bed is now obscured and only fragments of it, and loose fossils derived therefrom, are available. Bed 7 is a readily recognizable horizon, and so is bed 4.

Hull wrote:[5] 'These upper beds have been swept off almost the whole of the Eyeford and Sevenhampton districts, but it is not improbable the bed of marl, 8 ft. thick, at Sevenhampton Common, is the basement bed of the series. I also found a small portion of a field near the south-east extremity of the area strewn over with fragments of white limestone, but no section of it occurs. A band of white limestone, with *Clypeus solodurinus*, Ag., extends from near Summerhill to Hill Barn, across the Stonesfield Slate ground, north

[1] Richardson, L., 'Excursion to the . . . North Cotteswolds,' *Proc. Geol. Assoc.*, vol. xviii, 1904, p. 405; see also 'Excursion to Bourton-on-the-Water . . .', *Proc. Cotteswold Nat. F.C.*, vol. xvi, pt. 1, 1907, p. 25.

[2] *Proc. Cotteswold Nat. F.C.*, vol. xxii. pt, 2 for 1925 (1926), pl. viii, fig 1.

[3] 'The Jurassic Rocks of Britain' (*Mem. Geol. Surv.*), vol. iv, 1894, p. 292.

[4] 'On the Further Extension of the Great Oolite in the North Cotteswolds,' *Proc. Cotteswold Nat. F.C.*, vol. xxii, pt. 3 for 1926 (1927), p. 219.

[5] 'The Geology of the Country around Cheltenham' (*Mem. Geol. Surv.*), 1857, pp. 61, 62.

of Naunton.' North-east by northward of the Eyford Stonesfield Slate district the White Limestone occurs over a considerable area and in isolated patches the limits of which are indicated approximately on Dr. Welch's map (p. 116). The rocks are locally much faulted; there is no section available; and the evidence is field-rubble. But this field-rubble is unmistakable: the white rock-fragments show up conspicuously on the arable grounds and fossils are locally abundant. The localities at which particularly fossiliferous rubble occurs are indicated by the numbers 92*a*, 99, 102, 103, 105, 114, 116, and 118, on the map (p. 116). Specimens of *Nerinaea* are very abundant and it is convenient to speak of the White Limestone in this 'Condicote District' as the 'Nerinaea Limestone.' The most fossiliferous rubble is seen in the neighbourhood of the 600-ft. contour-line on the fields east and north-east of Swell Wold Farm.

An ammonite [Reg. No. 48482], recently found near the base of the White Limestone (a few feet above the Marly Beds), in the quarry about ½-mile N.W. by W. of Salperton Church, was identified by S. S. Buckman as *Tulophorites* aff. *tulotus* S. S. Buckman. According to Buckman this would date the beds as of Tulitan age, and of *Tulophorites* hemera, the date of the top bed of the Thornford Beds, Dorset.

Appended is a list of the fossils that have been noted in the White Limestone rubble at the localities indicated by the numbers which correspond to those on the map (p. 116).

	92	98	99	102	103	105	114	118
Amberleya sp.					*			
Nerinaea sp.		x	x	x	x			
Pseudomelania sp.			x					
Trochotoma sp.					x			
Lima cardiiformis *Morris & Lycett* [Z. 3944]					x			
Pholadomya heraulti M. & L ...								x
Rhynchonella (Burmirhynchia) patula *S. Buckman*	x	? x			x	x	x	
——(Burmirhynchia) oxoniensis *S. Buckman*	x			x	x*		x	
Terebratula sp.					x*			
—— sp.					x*		x*	
—— sp.	x*				x*		x*	
—— sp.						x		
—— sp.	x*				x*	x		
Cyathopora sp.					x			
—— waltoni (*M. Edw. & Haime*) ...				x				
Isastraea		x					x	
Montlivaltia sp.		x						
Thamnastraea lyelli *M. Edw. & Haime*		x						

* Test beekitized.

Forest Marble

Forest Marble has been detected at three localities in the North Cotteswolds, namely: (1) at ¼-mile W.N.W. of Fox Farm, near Condicote (119 on the map, p. 116); (2) at ¼-mile S.E. of Swell Wold or, as they are locally known as, Barn Cottages (116 on the map); (3) in the N.E. corner of the field west of Swell Wold Farm, south-westward of Fox Farm (100 on the map).

There are no sections and the evidence is field-rubble. At the first two localities the rock is blue, flaggy, shelly (principally by 'whitened' oysters) limestone, with a few bits of lignite: at the third, shelly (mostly 'blue-tinted' oysters) limestone with included subangular fragments of White Limestone derived from the White Limestone subdivision of the Great Oolite.. Locally, there is evidence that clay is associated with the limestone.

CHAPTER VI

SUPERFICIAL DEPOSITS

Superficial Deposits are extensively distributed over the Lower Lias of the valeland; occur some way up valleys that incise the hills; and are met with, but only rarely, on the upland of the hills. Many geologists have studied them, and the results of their investigations, together with additional information and suggestions as to the conditions under which they were laid down, are given in papers by J. W. Gray published in 1911[1] and 1912.[2] They have been mapped for the purpose of the Drift Edition of the New Series map, Sheet 217, by H. G. Dines, who has also determined the sequence of the constituent deposits as set out in this chapter.[3]

Vale of Evesham.—The deposits of the Vale of Evesham fall into four classes—in descending sequence:

River Gravel
Boulder Clay
Cheltenham Sand and Gravel
Unbedded Limestone Gravel.

Unbedded Limestone Gravel (Downwash Gravel)

This occurs at Broadway, Laverton, Stanway, ½-mile N.W. of Hayles, Noverton, and Syreford. The limestone fragments which constitute the bulk of this deposit are subangular and the gravel is compact and generally unbedded and ungraded, but tends to show signs of bedding at lower levels. The matrix is of comminuted limestone and forms a small proportion of the whole, merely filling spaces between the closely packed limestone fragments. The occurrences do not appear to have any definite connexion with present streams and seem to be accumulations of limestone débris collected at the foot of the steeper slopes of the hills, the patches lying usually at or near the 300-ft. contour. They probably formed a supply of material for the later gravels of the district though some of the spreads may have accumulated at later dates.

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[1] 'The North and Mid Cotteswold and the Vale of Moreton during the Glacial Epoch,' *Proc. Cotteswold Nat. F.C.*, vol. xvii, pt. 2, 1911, pp. 257-274.

[2] 'The Lower Severn Plain during the Glacial Epoch,' *Idem.*, vol. xvii, pt. 3, 1912, pp. 365-380.

[3] 'See also Dines, H. G., 'On the Glaciation of the North Cotteswold Area,' 'Summary of Progress' for 1927 (*Mem. Geol. Surv.*), 1928, pt. 2, pp. 66-71.

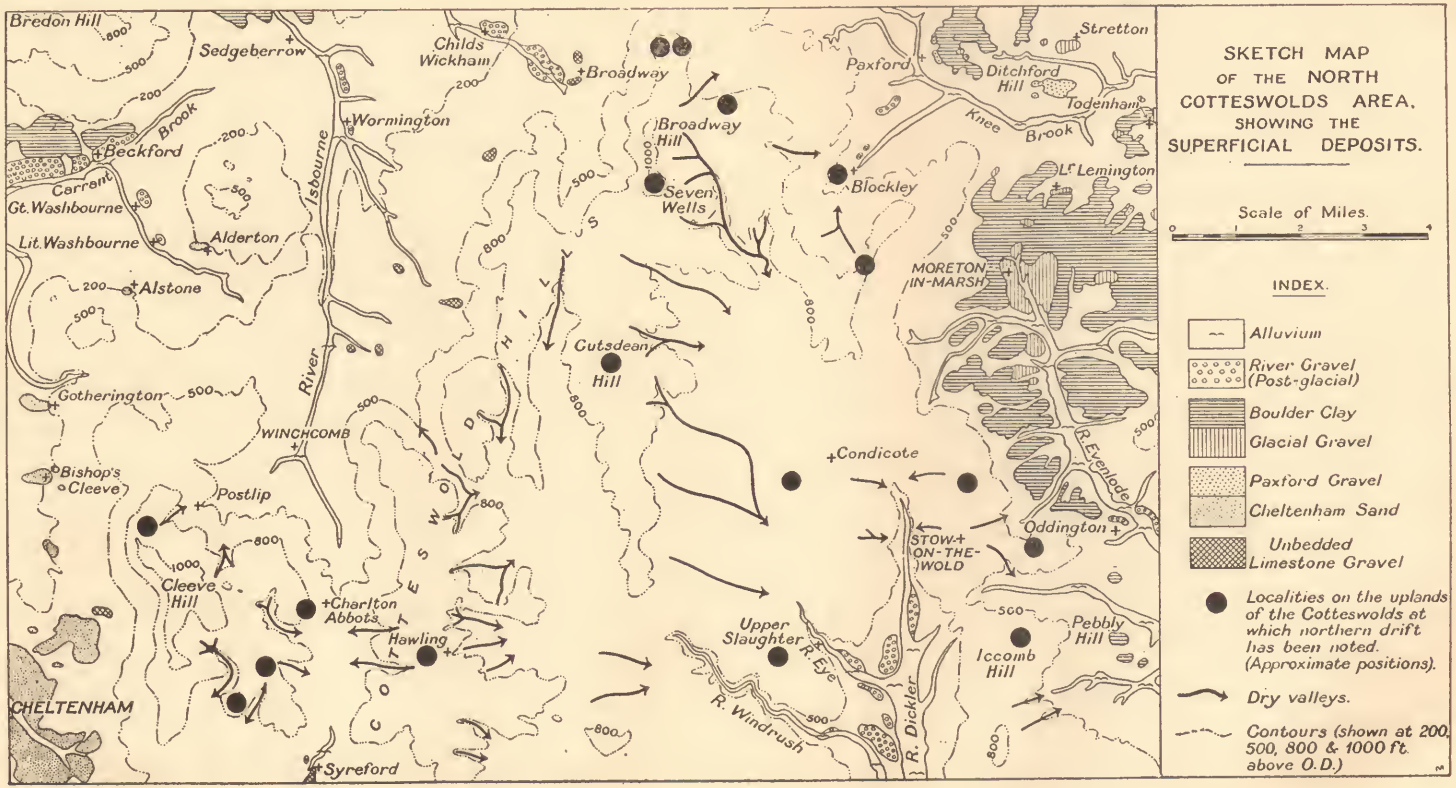

FIG. 8.—*Sketch-map of the North Cotteswold area, showing the Superficial Deposits.*

Details

In St. Michael's churchyard at Broadway a small pit shows 2 ft. of compact subangular limestone gravel with no evident bedding. At Laverton an excavation at a bend in the road near the village hall exposed 1½ ft. of similar gravel. The spread at Stanway is exposed in a pit on the south side of the road near the 11th milestone from Tewkesbury and ½-mile south-east of the church.[1] Here 1½ to 3 ft. of dark loamy soil with a few limestone fragments rests on 7 ft. of compact limestone gravel showing neither bedding nor gradation. The stones, which occur in all sizes up to 6 or 8 in. across, are set irregularly in a compact mass, the interstices being filled with comminuted limestone. All constituents are of local origin. A spread of similar gravel is shown in section in the railway-cutting ¾-mile west of Stanway church. The small patch about ½-mile north-west of Hayles does not appear to exceed 3 ft. in thickness. Compact irregular limestone gravel is to be seen in an old pit near Millhampost. Lucy says[2] that the Oolitic detritus, that is, this limestone gravel, " extends up to Winchcombe, where at an elevation of 300 ft., on table land, at the back of the town, is a gravel pit of 8 ft. of subangular Oolite, with some Lias Gryphites. Gravel of like character, I am informed, occurs under part of the town." At Noverton, about two-fifths of a mile N.E. by E. of Prestbury Church, is a large gravel pit showing now 5 to 7 ft. of dense limestone gravel, overlain by 6 in. of stiff brown clay and 3 ft. of bedded buff loamy brickearth. Many fossils, derived from the Lias and Oolite of the hill-side, are to be collected.[3] At Syreford, on the east side of the valley opposite the mill, a pit shows 7 ft. of dense limestone gravel. According to H. G. Dines, this gravel, although it occurs in a valley, is similar in texture to the other unbedded gravels and shows no indication of river deposition.

Cheltenham Sand and Gravel

This deposit occurs in large spreads at Cheltenham, Charlton Kings and Prestbury, and in small isolated remnants to the west of Southam, at Bishop's Cleeve, Gotherington, Alstone and Alderton. The smaller spreads are not evident from surface features and are mapped only on the contrast between the loamy soils they produce and the heavy clay soil of the Lower Lias.

As remarked by Mr. Dines a notable point in connexion with the occurrences at Alderton, Alstone, Gotherington, Bishop's Cleeve and Southam is that they lie at a uniform level, 200 ft. above O.D.

Details

At Alderton the sand has been worked in a pit about 10 ft. deep, now overgrown,[4] and 10 ft. of sand were said to have been passed through in a well sunk in the village. The small occurrence at Alstone is exposed in an orchard to the south of the village : near by is an overgrown pit from which, it is said, " many cartloads of good sand have been drawn." There is a considerable admixture of gravel with the sand, the gravel consisting of pieces of Marlstone and of ferruginous layers of Middle Lias from the neighbouring hill : no fragments of Oolite were observed. The Gotherington spread is not exposed;

[1] Lucy, W. C., ' The Gravels of the Severn, Avon and Evenlode, and their extension over the Cotteswold Hills,' *Proc. Cotteswold Nat. F.C.*, vol. v, 1872, p. 88.

[2] *Proc. Cotteswold Nat. F.C.*, vol. v, 1872, p. 88.

[3] Richardson, L., ' Handbook to the Geology of Cheltenham,' 1904, pp. 193, 194.

[4] See also Lucy, W. C., *Proc. Cotteswold Nat. F.C.*, vol. v, 1872, p. 88.

the loamy nature of the soil renders it suitable for cultivation, and a thickness of 4 ft. of sand with gravel in the lower part has been proved at several points by auger. Temporary excavations at the cross-roads ½-mile west of the village showed gravel and sand occurring sporadically in pockets in the Lias. At Bishop's Cleeve a pit near the church shows the following section :—

Sand-pit near Bishop's Cleeve Church

	Ft.
Black loamy soil with a few limestone pebbles	2-2½
Orange to brown coloured loamy sand	1-1½
Pale yellow sand	1
Fine gravel, replacing the sand above where thick ...	½-1½
Buff sand with discontinuous seams of clay ½ in. thick near the base	4
Fine limestone gravel	½
Buff sand ... ... seen to	2

According to Mr. Dines " this spread appears to be more gravelly towards the west, near the Smithy where there are some disused pits in limestone gravel. Gravel and sand were thrown up from a temporary excavation along the main street for a distance of about 400 yds. east of the church, and south of the railway station 3 to 4 ft. of limestone gravel is exposed in a shallow cutting. The occurrence at Southam appears to be mainly gravelly but is not exposed in section."

The greater parts of the built-over portions of Prestbury, Cheltenham and Charlton Kings, are situate on the Cheltenham Sand and Gravel. The distribution of this deposit and of the other Superficial Deposits in the areas represented on the 6-inch maps, Sheets xxvi. N.E. and S.E., has been shown by geologically coloured publications of these maps prepared by the writer. For full particulars of the Superficial Deposits of these areas the reader is referred to these maps and to the accompanying explanatory memoirs.[1]

At Hopwood's Nurseries the deposit is said to be 40 ft. thick ; at Ryeworth, Charlton Kings, 32 ft., " where it rests on rather coarser gravel, covering up the Lias clay "[2] ; and at The Diamond Laundry, Charlton Kings, 31½ ft. (well).

Cooper's Sand Hole, Ryeworth, has been long abandoned and is now occupied by a garden[3] ; the large sand-pit near The Diamond Laundry, however, exposes 25 ft. of the beds.[4] Sand is dug extensively at the Battledown Brick Works and close alongside the Cirencester Road at ¼-mile N.W. by N. of Charlton Kings church. The samples of sand examined by Dr. H. H. Thomas[5] and Dr. W. F. Fleet[6] were collected at the Battledown Brick Works where the sand is as free from gravel as anywhere. According to Dr. Thomas : " The sand is fairly uniform in grain, non-calcareous, and consists chiefly of sub-rounded quartz with a subordinate amount of orthoclase. The heavy residue is small, but interesting ; it consists of pink garnet, staurolite, and well-rounded tourmaline, and a few grains of the usual minerals of sedimentary rocks which have no value for the purpose of tracking a sand to its source. The relative abundance of staurolite in the heavy residue would certainly lead me to infer that the Trias had furnished most of the material. . . ."

[1] *Proc. Cotteswold Nat. F.C.*, vol. xvii, pt. 3, 1912, pp. 297-310 ; *idem*, vol. xviii, pt. 2, 1913, pp. 125-136.

[2] Lucy, W. C., *Proc. Cotteswold Nat. F.C.*, vol. v, 1872, p. 88.

[3] Richardson, L., ' A Handbook to the Geology of Cheltenham . . . ', 1904, p. 193, and pl. xii.

[4] Richardson, L., *Proc. Cotteswold Nat. F.C.*, vol. xvii, pt. 3, 1912, pl. xxxvi.

[5] *Proc. Cotteswold Nat. F.C.*, vol. xvii, pt. 3, 1912, p. 305.

[6] *Idem*, vol. xxii, pt. 2 for 1925 (1926), p. 188.

A.—RAILWAY CUTTING BETWEEN LECKHAMPTON AND CHARLTON KINGS STATIONS. CHELTENHAM SANDS (SUPERFICIAL) RESTING ON LOWER LIAS CLAY.

B.—RAILWAY CUTTING BETWEEN LECKHAMPTON AND CHARLTON KINGS STATIONS. CHELTENHAM SANDS (SUPERFICIAL) RESTING ON LOWER LIAS CLAY—CLOSE VIEW SHOWING DETAILS OF CHELTENHAM SANDS.

Dr. Fleet says: "Fine-grained, loose, brownish or fawn-coloured sand, apparently smooth-grained to the touch. The heavy residue in general is like that of samples from Mickleton and Bretforton, and resembles generally the residues of Triassic (Bunter) sediments in the Midlands. Under the microscope the grains are seen to be very considerably rounded and I should say that the deposit is a good example of an aeolian sand: indeed, some of the grains are beautiful examples of wind-rounding—about the best I have seen." Mr. Dines, however, states: "There appears to be no evidence of wind-blowing of the sand *in situ*; in practically all the exposures interbedding with limestone gravel is seen, and quartz grains in the sands at all levels are well rounded, indicating that they were subjected to wind action before being deposited in the Cheltenham Sand."

At the present time the Cheltenham Sand and Gravel is being actively worked by the Great Western Railway Company in the cutting between the Old Bath Road and Sandy Lane, Cheltenham (300 ft. O.D.), between Leckhampton and Charlton Kings Stations. A general view is given in Pl. v, A, and a detailed view of a portion, to show the mode of occurrence of the Jurassic fragments, in Pl. v, B.

The writer has not found, nor has he heard of anyone else having found, fragments of marine shells in the Cheltenham Sand and Gravel. Remains of mammoth[1] and a deer horn have been found in the deposit in the railway-cutting between Leckhampton and Charlton Kings Stations,[2] and *Elephas primigenius* has been recorded "in the gravel at Southam."[3]

Boulder Clay

Spreads of Boulder Clay lie to the north of Sedgeberrow and at Beckford and remains of this drift cover the low ground to the west and north of Dumbleton Hill and south of Blake's Hill.

Details

North of Sedgeberrow the red-brown loamy soil of the Boulder Clay is under cultivation. It contains Bunter quartzite and quartz pebbles, small angular flints and other stones of northern origin. Northern pebbles are abundant in the soil to the south of this occurrence, and along the upper part of the valley of the Carrant Brook. Loamy clay with many stones, including Bunter quartzite and quartz pebbles, flints, chert, etc., indicates the presence of Boulder Clay along the northern slopes of the valley of the Carrant Brook from Beckford towards the west. The Boulder Clay here appears to be overlaid by the river gravel.

River Gravel

River gravels occur at Broadway, Childs Wickham, Wormington, ¾-mile north of Wormington, Sedgeberrow, Great Washbourne, Little Washbourne, Beckford and south of Overbury. They consist of current-bedded sand, usually of coarser grade than that of the Cheltenham Sand, with beds of gravel composed mainly of limestone, but in most instances with northern pebbles, which indicate a post-glacial age of the deposit.

[1] Some of these, presented by S. S. Buckman, are now in the Cheltenham Municipal Museum.

[2] *Proc. Cotteswold Nat. F.C.*, vol. xvii, pt. 3, 1912, p. 310; *idem*, vol. xviii, pt. 2, 1913, p. 136.

[3] Murchison, R. I., 'Outline of the Geology of the Neighbourhood of Cheltenham,' 2nd ed. by H. E. Strickland and J. Buckman, 1844, p. 92.

Details

About ¼-mile north-west of Broadway church a large pit shows 10 ft. of bedded sand and gravel. In the upper half of the face there are only traces of bedding, but below the deposit consists of alternating bands of sand and gravel, about 6 in. thick evenly bedded. All the pebbles are well worn and no northern stones have been noted *in situ* in the exposure. There are no exposures in the gravel at Childs Wickham. A pit in the spread north of Wormington shows 4½ ft. of compact gravel mainly composed of well-worn limestone fragments, but with some northern pebbles in the upper part. The matrix is clayey and appears to consist of finely comminuted limestone ; no quartzose sand is present. The small occurrence at Sedgeberrow is exposed in a pit which shows 2 ft. of dark loamy soil with large fragments of limestone, and pebbles of Bunter quartzite and sandstone up to 6 in. diameter, also subangular flints 6 or 7 in. long with a brown patina. This rests on 3 ft. of bedded sand and gravel composed mainly of limestone fragments, but with occasional flints and other northern stones. There is a small pit at Little Washbourne showing 3 ft. of gravel. The gravel is composed principally of waterworn fragments of Marlstone, of ferruginous layers and nodules in the Middle Lias, and of Upper Lias limestones. At the porch of the house near by are some larger Bunter quartzite pebbles said to have come from the bottom of the pit. At Great Washbourne a disused excavation exposes 6 ft. of sand with thin streaks of gravel. Sand and gravel has been extensively worked to the north of Beckford, by the side of the road to Grafton. The pit was opened for ballast during the construction of the Ashchurch and Evesham railway.[1] Now it is in intermittent use and shows 7 ft. of current-bedded sand and gravel. The latter is fine-grained, oversize from a 1½ in. mesh being uncommon. The gravel is composed of rolled fragments of Marlstone, Upper Lias and Inferior Oolite limestones, but some large blocks of only slightly waterworn Marlstone are to be met with in the deposit. White vein-quartz, Bunter quartzite pebbles and chert are present, and slightly worn flint chips with cream or ochreous patina are fairly common. Sir William Guise, in his Presidential Address to the Cotteswold Naturalists' Field Club, stated that when at Beckford, in company with the Rev. W. S. Symonds, he found a fragment of a shell which Gwyn Jeffreys pronounced to be a portion of *Lucina borealis*, and Miss Holland (later Mrs. Hutton) is said to have found a *Rissoa* at the same place. In Boyd Dawkins's list[2] of post-Glacial mammals the following mammalia are noted under the locality "Beckford": *Cervus tarandus* Linn., *Bos primigenius* Bojanus, *Bison priscus* Owen, *Sus scrofa* Linn., *Rhinoceros tichorhinus* Cuv., and *Elephas primigenius* Blum. About 1¼ miles south of Overbury the following section has been noted by Mr. Dines in a pit worked exclusively for building sand :

Sand-Pit near Overbury	Ft.
Brown humus with a layer of stones, mostly of Bunter quartzite, quartz or flint	2
Brown loam, paler than above	1
Gravel, mainly of limestone fragments, but with Bunter quartz and flint—some large	1½
Sand with a few small pebbles including some of Bunter and quartz...	1
Alternating layers of sand and clay 2 in. thick	¾
Fine gravel, sandy above and compact below, mainly of limestone, with a few slightly worn flints, but no Bunter or quartz pebbles seen	2½

[1] Lucy, W. C., *Proc. Cotteswold Nat. F.C.*, vol. v, 1872, pp. 84, 85 ; see also Lloyd, T. G. B., "On the Superficial Deposits of Portions of the Avon and Severn Valleys and Adjoining Districts," *Quart. Journ. Geol. Soc.*, vol. xxvi, 1870, pp. 210, 211.

[2] *Quart. Journ. Geol. Soc.*, vol. xxv, 1869, p. 195.

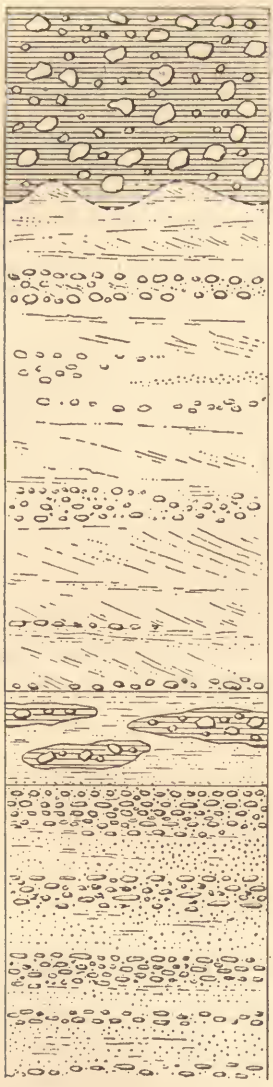

FIG. 9.—*Diagrammatic section showing the sequence of Superficial Deposits in the Vale of Moreton as exposed in the gravel-pit 1¼ miles E. of Upper Lemington.*

The small spreads resting on the Boulder Clay to the north-west of Beckford, and to the south of Overbury and Conderton are probably not more than thin washes of gravel.

River Development

According to Mr. Dines: "The distribution of the River Gravels in the Vale of Evesham indicates a modification, at a comparatively recent date, of the drainage system of the area. The gravel at, and west of, Beckford, could not have been laid down by the Carrant Brook, which rises in the Lias country about a mile south of Sedgeberrow, and the Isbourne Valley is without gravel except for the small spreads at Wormington and Sedgeberrow.

It appears probable that a stream flowed into this district, near Sedgeberrow, from the north and followed the valley of the Carrant Brook towards the west, with tributaries flowing from the Cotteswolds in a general north-westerly direction, one through Winchcomb and the Washbournes, another through Wormington, and a third through Broadway and Childs Wickham. The arrangement of the deposits of River Gravel points to such a system of streams.

The Isbourne is apparently the result of some change of drainage in the area to the north of the present district. Though it has the largest catchment basin on the western side of the Cotteswolds, its valley is lacking in gravels, except at Wormington and Sedgeberrow, where its course follows that of a previous tributary to the stream from the north. Moreover, the watershed between the Carrant Brook and the Isbourne is situated within a mile of the latter stream, and that between the stream that flows past the Washbournes and the Isbourne is within half a mile. The watersheds referred to are a mile south of Sedgeberrow, and five-eighths of a mile north-west of Toddington church respectively, and their close proximity to the Isbourne shows that that stream is of a later date than the Carrant Brook and its tributary."

Vale of Moreton.—The order of the Superficial Deposits on the eastern side of the Cotteswolds, in descending sequence, determined by Mr. Dines is as follows:—

River Gravel
Boulder Clay
Glacial Sand and Gravel
Paxford Gravel

Paxford Gravel

Pre-Glacial River Gravel occurs at Paxford, Ditchford Hill, and north of Wolford Wood on the eastern margin of the district. At Paxford and Ditchford the deposit, part of a pre-glacial river-terrace, consists of compact (mostly Oolitic) limestone gravel, which is overlaid by Boulder Clay. Near Wolford Wood it consists of bedded layers of yellow or buff quartz sand and limestone gravel, thus resembling the Cheltenham Sand and Gravel. It is difficult not to adopt the view straightaway that the sand and (limestone) gravel of Wolford Wood is contemporaneous with the Cheltenham Sand and Gravel. Mr. Dines explains the absence of sand from the gravel at Paxford and Ditchford by the inference that sand was absent from the drainage-basin of the pre-glacial Knee Brook.

Details

About ¼-mile north-east of Paxford Church a pit, noticed by W. C. Lucy,[1] shows the following section :—

Paxford Gravel Pit

		Ft.
	Soil	1
Boulder Clay	Red-brown loam with streaks of purplish clay and stones, including limestone fragments and northern pebbles	1 to 5
Pre-Glacial River Gravel	Limestone (mostly Oolite) gravel, waterworn, very compact but bedding shown by thin streaks of grey clay. In some parts the gravel is cemented with calcite : seen ...	15 to 20

A large flint, still retaining its original cortex was found in the red-brown loam. The Pre-Glacial River Gravel (Paxford Gravel) is free from northern stones and the workmen said that they had not come across any mammalian remains. About ¼-mile north of the above pit another shows 6 ft. of compact, slightly bedded gravel, without either quartzose sand or northern stones. The occurrence of Paxford Gravel at Ditchford Hill is not covered with drift, but an excavation in the gravel shows :—

Ditchford Hill Gravel Pit

		Ft.
Pre-Glacial River Gravel	Limestone (mostly Oolite) gravel, waterworn, compact, with a fissure in the gravel filled to a depth of about 4 ft. with red-brown or purplish Boulder Clay containing bits of white chalk and a few northern pebbles	6

An interesting section is displayed on the eastern margin of the district near Wolford Wood.

Pit near Wolford Wood

		Ft.
Glacial Sand and Gravel	Red coarse grained loose sand with Bunter quartzite pebbles, flints and abundant quartz pebbles. In one part of the pit face, near the base of the deposit, are lenticles of purplish Boulder Clay (up to 1 ft. in thickness) and green clay	10
Pre-Glacial River Sand and Gravel	Yellow or buff sand, evenly bedded with layers of fine gravel, composed entirely of well water worn limestone : seen	6

The sand of the Pre-Glacial deposit is of finer grade than that of the Glacial deposit. About ½-mile west of the above, another occurrence appears to consist of compact limestone gravel : an old pit in this spread is 4 ft. deep.

[1] *Proc. Cotteswold Nat. F.C.*, vol. v, 1872, p. 97.

Glacial Sand and Gravel

This is widely distributed on the eastern side of the Cotteswolds at between 400 and 450 ft. above O.D. It is seen to underlie the Boulder Clay near Paxford, at Toddington and around Moreton in Marsh, and it also occurs at Stretton on Fosse, Aston Magna, Lower Lemington and on the eastern margin of the district due east of Upper Lemington. In the northern part of the district the deposit consists of coarse current-bedded sand, buff to pink or reddish in colour, interbedded with thin streaks of northern pebbles at various levels. At Moreton in Marsh it is a typical glacial gravel, the upper part of which has been disturbed.

Details

At Stretton on Fosse are two pits: the one (1) about 100 yds. west of the church; the other (2) 300 yds. to the south (of the former pit).

Stretton on Fosse: *Sand-Pit No.* 1

		Ft.
Boulder Clay	Masses of limestone débris and rafts of red or purplish clay in a clayey matrix containing northern pebbles occurring in pockets, to a depth of	6
Glacial Sand and Gravel	Pink or red current-bedded sand, with thin layers of northern pebbles: seen	12

Stretton on Fosse: *Sand-Pit No.* 2

		Ft.
Boulder Clay (basal gravel)	Fine (mostly Oolite) limestone gravel with northern material, much current-bedded, and locally stained black	0 to 8
Glacial Sand and Gravel	Pink or reddish beautifully current-bedded sand with seams of pebbles of Bunter quartzites, quartz, Carboniferous chert, flint—but devoid of pebbles of local rocks: seen ...	12

The Boulder Clay in the above sections is of the age of the Black Downs deposit (see p. 132). Some of the Bunter quartzite and quartz pebbles attain a size of 8 in. across, and a sarsenstone 2 ft. across has been seen in the pit. The sand is ochreous at the base.

On the eastern margin of the district is the pit near Wolford Wood already referred to (p. 129) in which is displayed 10 ft. of Glacial Sand and Gravel resting on the Pre-Glacial deposit.

The large spreads around Moreton in Marsh are now only exposed in small pits about ½-mile east of the town. The section seen here (1928) consists of 3 to 4 ft. of gravel with a red clayey matrix in which the stones occur in irregular masses. The stones are in many instances orientated vertically; a phenomenon which may be attributed to alternate freezing and thawing of the soil. The above rests on 2 ft. (exposed) of orange coloured gravel with a coarse sandy matrix. There is a total absence of grading in the gravel, large Bunter and quartz pebbles, flints, blocks of coarse grit or sandstone, etc., being intermixed with the smaller stones.

These Moreton gravels have been studied by many geologists, a number of whom have published observations.[1]

The sections at Lower Lemington, Aston Magna,[2] Dorn,[3] and Four Shire Stone are now obscured. In the railway-cutting at Aston Magna, G. E. Gavey observed very large chalk flints, " many of them weighing one to two cwt. each." " These are intermixed with blocks of hard Chalk, Greensand, and clay, together with a quantity of siliceous sand and pebbles."

This section is now overgrown, but it seems probable that the large flints and the Chalk referred to are in a deposit of Boulder Clay.

Boulder Clay

The Boulder Clay appears to have once extended as a continuous sheet from the north of the district along the Valley of the Evenlode : this has been dissected by the Knee Brook, the Evenlode and its tributaries. Passing southward the spreads converge towards Oddington where the valley is narrowed by the projection of a spur from the hills at Stow on the Wold ; and south of this the deposit continues along the valley as smaller spreads west of Bledington Heath, at Pebbly Hill, at Bowl or Bould (Sheet 218) and beyond. It lies at a nearly uniform level between 400 and 450 ft. above O.D. rising to above 500 ft. at one locality, a mile north-east of Paxford. In sections the deposit is seen to consist of a plastic clay, sometimes loamy, and generally red-brown to purple in colour, but occasionally grey. It carries northern pebbles irregularly scattered throughout. These in most cases are small, averaging about 2 in. diameter, but boulders are not uncommon. Chalk has been noted in the clay near Marefurlong, but elsewhere it is of very rare occurrence. The proportions of the northern stones vary in different localities ; quartz pebbles predominating east of Wolford Wood, and small flints, north of Dorn. In many localities where the Boulder Clay areas are under cultivation the stony soil is seen to have a red tinge, and the quantity of stones in the clay varies from place to place. The full thickness of the deposit is nowhere shown in section, but the maximum is estimated to be about 8 ft.

Details

In the small gravel pit ¼-mile east of Paxford church, 3 ft. of red clay with northern pebbles is seen resting on the Pre-Glacial River Gravel. At Black Downs, a mile west of Stretton on Fosse a large pit, mostly overgrown, shows

[1] Buckland, W., *Trans. Geol. Soc.*, vol. v, 1821, p. 518 ; 'Reliquiae Diluvianae,' 1823, pp. 250, 251 : Lucy, W. C., *Proc. Cotteswold Nat. F.C.*, vol. v, pp. 101, 102 : Buckman, S. S., ' Gravel at Moreton-in-Marsh (Gloucestershire),' *Quart. Journ. Geol. Soc.*, vol. lv, 1899, p. 220 : Reade, T. Mellard, S. S. Buckman, and C. Callaway, ' The Gravel at Moreton-in-the-Marsh,' *Proc. Cotteswold Nat. F.C.*, vol. xiv, pt. 2, 1903, pp. 111-118 : Callaway, C., *Proc. Geol. Assoc.*, vol. xviii, pt. 8, 1904, p. 407 ; ' The Occurrence of Glacial Clay on the Cotteswold Plateau,' *Geol. Mag.*, 1905, p. 218 ; Salter, A. E., ' On the Superficial Deposits of Central and Parts of Southern England,' *Proc. Geol. Assoc.*, vol. xix, 1905, pp. 38, 39 : Harmer, F. W., ' On the Origin of Certain Canon-like Valleys,' *Quart. Journ. Geol. Soc.*, vol. lxiii, 1907, p. 500.

[2] Gavey, G. E., ' On the Railway Cuttings at the Mickleton Tunnel and at Aston Magna, Gloucester,' *Quart. Journ. Geol. Soc.*, vol. ix, 1853, p. 35.

[3] *Idem*, p. 36.

a mass of large, mostly Lower Lias, boulders, 1½ to 2 ft. diameter being not uncommon, set irregularly in a matrix of clayey material with flints and northern pebbles (mostly small). This basal portion of the Boulder Clay appears to be a mixture of the material brought from the north by the ice sheet and the accumulation contained in the local sedentary ice, and rests on Lower Lias. W. C. Lucy writes[1] : " At Blackdown the section shows a depth of nearly 20 feet, but Mr. Fletcher, upon whose property it is, informs me that there is Gravel 5 feet lower than was being worked when I was there." Lucy gives the following section :—

	Ft.	Ins.
" Soil and pebbles	1	6
Coarse Gravel, with Flints	3	0
Fine Gravel and Sand, with occasional small boulders ...	6	0
Fine laminated sand resting on coarse N. D. Gravel and Flints with large rolled Lias Pebbles	9	0
Lower Lias."		

and adds : " There are some large Millstone Grit and Lias boulders, Gneiss, fine Quartz, Brownstone from the Old Red Sandstone, Pebbles, and Cretaceous Flints. . . . Near the pit, from which it had been removed, I observed a piece of Hornblende Greenstone, 2 ft. 3 in. long, 9 inches thick, and 15 inches wide."

Remains of a similar deposit are to be found in pockets in the surface of the Glacial Sand and Gravel at Stretton on Fosse, where irregular accumulations of local material occur with ' rafts ' of red clay.

Temporary excavations along the Fosse Way, south of Moreton in Marsh, where it passes over a number of small spreads of Boulder Clay, showed alternately red clay with stones and grey clay of the Lower Lias. Purple clay has been excavated from the graves in Evenlode churchyard. About ⅓-mile south-east of the church the deposit consists of a reddish loam resembling brick earth.

River Gravel

The gravels of the existing drainage system occur principally at and north of Blockley, around Lower Slaughter and Bourton on the Water, and near Oddington. With the exception of the Oddington occurrences, the gravels of this class have been deposited by streams, the catchment areas of which are separated from the Boulder Clay and Glacial Sand and Gravel tracts ; they are therefore mainly of local origin, only one small fragment of flint having been found *in situ* in the gravel near Bourton on the Water. The gravel at Oddington, on the other hand, consists chiefly of northern pebbles.

Details

A small pit ½-mile north-east of Blockley church shows 4 ft. of well-rounded limestone gravel. The pebbles lie in a horizontal position but there is no other evidence of bedding. Quartz sand is absent.

E. Hull said[2] : " South of Stow the western limit of the Northern Drift is very well defined. The line follows the western flank of the Bourton Valley, thence trends along the southern bank of the Windrush River, nearly as far as

[1] *Proc. Cotteswold Nat. F.C.*, vol. v, 1872, p. 99.

[2] ' On the Physical Geography and Pleistocene Phaenomena of the Cotteswold Hills,' *Quart. Journ. Geol. Soc.*, vol. xi, 1855, p. 493.

Burford." The writer[1] and A. E. Salter,[2] however, have not detected any Bunter pebbles in the portion of the Vale of Bourton that comes within the area of this Sheet. The river (Jurassic) gravel commences in quantity where the Rivers Dikler, Eye and Windrush, flow out of the hill-country into the vale. There are pits in it close to the main road about half-way between Stow and Bourton (at about 450 ft. above O.D.), at Lower Slaughter (450 to 460 ft.), and at Bourton on the Water (425–435 ft.) where " bones of elephants " are said to have been found.[3] All the pits display about 10 ft. of compact limestone gravel, showing bedding and current bedding, and in most cases the top 3 or 4 ft. is somewhat contorted. The only northern material found consisted of a small fragment of flint found *in situ* in the gravel of one of the pits between Bourton and Stow.[4]

Limestone (Jurassic) gravel is also found locally higher up the valleys of the Dikler, Eye and Windrush : of the valley of the Dikler in the vicinity of Waterhead Barn (about 550 ft. above O.D.) above Donnington Mill[5] ; of that of the Eye at ¾-mile north of Eyford Park (about 550 ft.),[6] and traces, well rolled, resting on Upper Estuarine Clay, in pond-sides five-twelfths (575 ft.) and ¾-mile (595 ft.) W.N.W. of Fox Farm, near Condicote ; and of that of the Windrush at Harford Bridge (485 ft.), between Bourton and Naunton.[7] For descriptions of the Rivers Dikler and Eye the reader is referred to papers by the writer.[8]

River Development

Mr. Dines contributes the following : " As in the Vale of Evesham, the distribution of the superficial deposits of the area east of the Cotteswolds shows a post-Glacial modification of the drainage system. A stream appears to have entered the district from the north and flowed southward along the valley of the Evenlode prior to and during the Glacial period. A post-Glacial date of the formation of the Knee Brook Valley is indicated by Glacial gravel and the Boulder Clay, which lie at approximately equal elevations above O.D. on either side of the valley. Thus a change of drainage in the area to the north of the present district has effected a capture of the upper part of the Evenlode which now rises near Moreton in Marsh."

The Uplands

There are no Superficial Deposits on the uplands of the Cotteswolds of sufficient extent to be represented on the map, " but, " in Mr. Dines's opinion, " traces of northern drift are sufficiently widespread over the area to indicate that at least the higher portions of the ice-sheet that brought the Boulder Clay from the north over-rode the northern part of the hills."

Hull[9] said : " The higher portions of the Cotteswold Hills . . .

[1] ' Excursion to . . . the North Cotteswolds,' *Proc. Geol. Assoc.*, vol. xviii, 1904, p. 402.

[2] *Proc. Geol. Assoc.*, vol. xix, 1905, p. 37.

[3] Lucy, W. C., *Proc. Cotteswold Nat. F.C.*, vol. v, 1872, p. 123.

[4] Richardson, L., *idem*, vol. xviii, 1904, p. 402.

[5] Richardson, L., ' Excursion to the North Cotteswolds,' *idem*, vol. xxii, pt. 2 for 1925 (1926), p. 69.

[6] Richardson, L., ' [Excursion to] Eyford Park and Icomb Place,' *idem*, vol. xxi, pt. 2 for 1922 (1923), p. 75.

[7] *Idem*, p. 74.

[8] ' The River Dikler,' *Proc. Cotteswold Nat. F.C.*, vol. xxii, pt. 2 for 1925 (1926), pp. 179-181 ; ' The River Eye,' *idem*, vol. xxii, pt. 3 for 1926 (1927), pp. 255-258.

[9] *Quart. Journ. Geol. Soc.*, vol. xi, 1855, p. 493.

appear never to have been overspread by Northern Drift. . . . In crossing the district from the western escarpment above Cheltenham towards the east, we meet with no erratic pebbles until we arrive at Stow on the Wold. . . ." (See p. 74). Later investigators, however, have found northern ("Northern Drift") material on this upland.

Scattered or single pebbles have been found at: Saintbury Hill (800 ft. above O.D.)[1]; Willesley Hill (890 ft.)[1]; ½-mile of Westington Hill Quarry, Chipping Campden parish, one quartzite pebble (about 890 ft.) (L.R.); ⅔-mile N.N.E. of Seven Wells—one quartzite pebble (about 920 ft.) (L.R.); Bourton on the Hill (800 ft.)[1]; ¼-mile W.S.W. of Fordhill Farm, Temple Guiting, one large Bunter quartzite pebble (985 ft.) (L.R.); Hawling (900 ft.)[1]; Charlton Abbotts (760 ft.)[1]; Puckham (900 ft.)[1]; Cleeve Cloud (1,000 ft.).[1] Bunter quartzite pebbles are met with in the gardens in front of Northwick Terrace, Blockley (about 540 ft.). The paths at the Springhill Lodge on the Snowshill Road are cobbled with large Bunter quartzite pebbles which are said to have been collected from the ploughed fields between the Lodge and Seven Wells (1,000 to 1,048 ft.). Similar pebbles are found occasionally on the fields around Condicote; several of these pebbles are to be seen on the window sill of the village Post Office.[2] The farmyard at Swell Hill Farm is also cobbled with similar pebbles that were picked off the fields. J. W. Gray says[3] that near Wagborough Bush, Upper Slaughter, "pebbles of brown quartzite, white quartz, flaked and unflaked flints, and waterworn pebbles of oolite occur in the clayey soil of a field [known as 'Gom's Hole'] just below the 700-ft. contour-line on the eastern side of the Buggilde [or Buckle] Street, about 200 yds. to the north of the lane leading from Harford Bridge to Slaughter Manor. This occurrence of unflaked flints is important as being among the very few on the Cotteswold Hills above an elevation of 650 ft." Mr. Dines informs me that he is disposed to regard the top foot or so of the clay where of a purplish tint at Bolton's Ground Quarry, near Condicote, as Boulder Clay (see p. 99): on a tip of this clay were found a Bunter pebble and some flints. Reddish soil with a few Bunter quartzite and quartz pebbles caps the quarry section in The Triangle alongside the Fosse Way, ½-mile west of Broadwell, near Stow on the Wold. This occurrence may be that noticed by Hull[4]: "... at Stow on the Wold, where in the Moreton Road, at an estimated height of 500 feet, we find the following section:—

	Ft.	Ins.
1. Brown loam	1	0
2. Soft white oolitic sand	0	5
3. Pebble bed; containing rounded grey and white quartz, black chert? flints, and grit, etc.	0	2
4. Reddish brown loam	0	6"

At one place in particular above the disturbed rock in the quarry on Martin's Hill, between Stow on the Wold and Oddington, is loamy purplish Boulder Clay with many northern pebbles.

A considerable portion of the face of the quarry seven-sixteenths of a mile N.50°W. of the Church, Iccomb, is covered with reddish Boulder Clay, with many northern pebbles, that has worked down fissures (700 ft.).

Further evidence of Glaciation.—According to Mr. Dines: "The absence of weathering to any considerable depth in the limestones on the high ground may be regarded as a fact supporting the view

[1] Gray, J. W., *Proc. Cotteswold Nat. F.C.*, vol. xvii, pt. 2, 1911, p. 260.
[2] Richardson, L., 'Excursion to the North Cotteswolds,' *idem*, vol. xxii, pt. 2 for 1925 (1926), p. 70.
[3] *Proc. Cotteswold Nat. F.C.*, vol. xvii, pt. 2, 1911, p. 260.
[4] *Quart. Journ. Geol. Soc.*, vol. xi, 1855, p. 493.

of over-riding of the ice-sheet. In most quarry faces weathering of the limestone does not penetrate beyond a few feet. In places where the weathering reaches a greater depth, however, the freed slabs of limestone are disturbed and disarranged as at Martin's Hill, east of Stow on the Wold.

" Although solution of the limestones may have played a part in the formation of the deep coombe-like valleys of the Cotteswolds it is probable that many were initiated as a result of drainage from a melting snow or ice-cap during times of thaw. Many of these commence in the flat plateau-like uplands, where no source of water supply is now available, and plunge rapidly down into deep gorge-like valleys which are now dry in the upper parts. Such may be noted at Postlip, Drypool, west of Charlton Abbots, east of and north of Hawling, south of Snowshill, south-east of Broadway Hill, south of Blockley, etc."

Gravels

Gravel accumulations are rare on the uplands of the Cotteswolds. The known occurrences are small in extent and consist of fine-grained limestone gravels and may be regarded as a type of Coombe Deposit.

Details

At Cleeve Hill, on the western side of the Postlip Valley at 800 ft. above O.D., a fine limestone gravel without bedding is worked in a pit 5 ft. deep. Just below the 700 ft. contour, west of Blockley church a similar deposit occurs. The limestone fragments do not appear to be much waterworn, and apart from the horizontal arrangement of the pebbles bedding is not indicated. At 600 ft. above O.D., on the west slope of the valley at Syreford, a pit shows 12 ft. of fine-grained limestone gravel with a reddish clayey matrix, showing distorted bedding due to creep down the hill slope. The top 2 or 3 ft. contains angular fragments of limestone up to about 6 in. across, but the lower part of the gravel averages about ½-in. mesh with occasional fragments up to 4 in.[1]

Alluvium

There is little Alluvium in this district : the largest tract is that situate in the neighbourhood of the junction of the River Dikler and River Eye (or Slaughter Brook) in the vicinity of Wyck Mill, near Bourton on the Water.

Landslips

Large masses of Inferior Oolite are to be met with at many localities far below the altitude of the true outcrop of the formation which have slipped down the hill-sides on the watery slope of the Upper Lias clay. Also they are to be met with at all stages of detachment from the parent mass : from the initial tilting vale-wards of the rock-mass (and production of open-fissure faults) to complete detachment and rest, far down the hill-sides.

[1] See also Richardson, L., ' Excursion to the Andoversford District,' *Proc. Cotteswold Nat. F.C.*, vol. xx, pt. 3 for 1920 (1921), p. 175.

The initial stage of a slip may be seen in the quarry south-west of the Fish Inn on Broadway Hill in which—in the western part—dislocated freestones have a vale-wards tilt with fissures between them and the parent-mass. A further stage may be seen between the quarry and Broadway Tower where a deep depression comes at the back of a down-hill slipped mass. Along the western slope of Cleeve Hill slipped masses are numerous and presented to Hull ' the aspect of marine undercliffs.'[1] At Spoonley, near Winchcomb, there is a large slipped mass—far below its normal position ; while, near by, towards the top of the valley-side immediately north of Lonehill Wood, is a platform-like tract a little below the level of the main Oolite mass which is obviously on Oolite on the downward trend. On the hill-side east of Stanway slips are very much in evidence and the rock is tumbled about in all directions. Slips of Oolite and Upper Lias clay encumber the hill-sides in the vicinities of Bourton on the Hill and Longborough and occasion much trouble to those concerned with finding foundations for buildings and with matters of water-supply. The Upper Lias ground between Upper Slaughter and Bourton on the Water is much obscured with slips : a quarry about $\frac{1}{3}$-mile south-westward of Lower Slaughter is in freestone and Clypeus Grit, pitching steeply towards the hill but on Upper Lias towards its lower limit. In the first cutting west of Bourton on the Water, on the railway to Cheltenham, the rocks are extremely disturbed, some of the strata being tilted at an angle of 55 degrees.

The most authentic case of a landslip occurred at Hewletts Hill, near Cheltenham, where "a large knoll of Upper Lias slipped from its place down an inclination of several hundred yards, taking trees and hedges along with it, and causing great derangement of the soil."[2]

What may be described as ' sluggish flowing ' of Upper Lias clay may be noticed at a number of localities, for example, in the neighbourhood of the footpath from (near) Broadway to (near) The Fish Inn that enables the pedestrian to avoid the southward bend of the road up the hill.

Early Man

No remains of Palaeolithic man have been found in the district, but there are on the hills numerous remains of Neolithic villages, tumuli, and flint-implements.[3]

[1] ' The Geology of the Country around Cheltenham ' (*Mem. Geol. Surv.*), 1857, p. 86.

[2] Murchison, R. I., ' Geology of Cheltenham,' new ed. by H. E. Strickland and J. Buckman, 1844, p. 59.

[3] For information concerning this subject the reader is referred to the following publications : Witts, G. B., ' Archaeological Handbook of the County of Gloucester ' 8vo, *Cheltenham* [1883] ; Smith, Vincent A., ' Pygmy Flints,' *Proc. Cotteswold Nat. F.C.*, vol. xv, pt. 3, 1906, pp. 215-225 ; and Crawford, O. G. S., ' Long Barrows of the Cotswolds . . . ', 8vo, *Gloucester*, 1925.

CHAPTER VII

ECONOMIC GEOLOGY

Agriculture[1]

The tracts in which Lower Lias occurs have soils which are naturally heavy ; the drainage is frequently bad and the land lies wet and cold in winter. From autumn to late spring much of the area is in a water-logged condition, the grass-land being uncomfortable for cattle during several months of the year. Permanent pasturage predominates, though locally wheat, oats, beans, ' seeds,' mangels and a few swedes are grown. The cereals are sown in the autumn as the soil does not dry out early enough in the year to rely upon planting spring varieties (*e.g.*, oats). A wet April delays the sowing of mangels until late in May, it being impossible to prepare a satisfactory tilth at the proper time.

During dry summers these heavy soils shrink badly and develop cracks, the subsoil drying through the cracks. So great is the shrinkage during periods of drought that houses built thereon frequently have their walls cracked and the drain-pipes disturbed.

Although land of this class is generally unsuited to intensive cultivation much might be done towards improving the drainage of the area. Opening up the arterial system of stream-courses and ditches would lower the water more quickly after rain ; the soil would warm more readily in spring ; seasonal growth would be earlier and the herbage of the grassland could be more easily improved. Towards this end, mole draining might be usefully employed where the land is not already tile-drained.

Manurial experiments in Blockley parish and at Murcot have shown that pastures on heavy soils readily respond to treatment with suitable phosphatic fertilisers. Basic slag and steamed bone flour have given the best results and it is conceded that one liberal application of either of these manures is more economical than two half dressings at triennial intervals. The former manure produces a close, clovery sward, while the latter encourages a growth of the better grasses among a prolific development of white clover runners. The effect of potash fertilisers, either alone or in conjunction with phosphatic manures, is practically negative, the amount of available potash being sufficient for the purposes of growth. Manuring, however, of any kind, is of little avail unless the drainage is satisfactory.

The principal pasture weeds are marsh bent grass (*Agrostis alba*), false brome grass (*Brachypodium sylvaticum*), and thorny rest-harrow

[1] This section is contributed by R. C. Gaut, M.Sc., Agricultural Organizer, Worcestershire County Council.

(*Ononis spinosa*). These disappear with suitable manuring and proper grazing. Ants are frequently troublesome on Lower Lias soils.

The management of the tillage requires some care as it is important to keep the surface soil on top. If deepening the tilth with the plough is contemplated it must be done gradually and, as an alternative, it is safer to use a sub-soiling attachment and plough at the ordinary depth in order to secure better drainage and aeration. Bare fallows are occasionally necessary for cleaning purposes and to restore the tilth.

The soil texture is best improved by liberal applications of farmyard manure which, during the process of decay, helps to lighten, drain and warm the surface soil : good crops of ' seeds ' (red clover or rye-grass and red clover) assist in the same way when the residue is ploughed under. Lime must be applied when this necessary soil constituent is lacking : it deflocculates the minute clay particles, thereby promoting drainage and also liberates potash from insoluble compounds. Lime should never be ploughed under ; it should be spread over the furrows and worked in during succeeding operations. As a top-dressing for roots or cereals nitrate of lime is preferable to nitrate of soda as the latter impairs the tilth by making the soil sticky.

The weeds of the arable land are ' couch ' or ' twitch ' (*Triticum repens*), black bent (*Alopecurus agrestis*) and field mint (*Mentha arvensis*).

Although Lower Lias soils are not strictly speaking fruit soils, apples do well on grass where the soil is not too wet and where planting has been done properly. Good planting is essential, the main point being to ensure that the roots are not water-logged in winter and that the site is above the spring frost line of adjacent depressions or hollows. Where the land is well laid up in ridges and furrows, surface drainage is easily secured, but under other conditions planting must be done practically on the top of the soil and the roots covered with a good compost of road-scrapings, wood-ashes and such lightening material.

The characteristic tree is the English elm which grows to considerable height and girth.

The sandy beds of the Middle Lias give rise to a loam typical of arable cultivation. At a few localities, for example, in the vicinity of Toddington ; on part of the south-westward facing slope of Alderton Hill ; and in the vicinity of Ashton under Hill, these beds have been planted with fruit-trees or cultivated for market gardens ; but on the eastern side of the North Cotteswolds their outcrop area is, as a rule, too exposed to the east winds to be suitable for cultivation for the purposes mentioned.

The Lower Lias clay ground west of the hills has locally on its surface patches of sand, sand and gravel, and gravel. Such ground is

in the main plough-land; but the tendency is on the increase—especially in such favourable neighbourhoods for marketing as those of Cheltenham, Broadway, and Ashton under Hill—to devote it to market-gardens.

Superficial Deposits also occur locally on the surface of the Lower Lias in the Moreton Valley. A little fruit-growing and market-gardening is done, but the crops are generally nearly a month later than those grown to the west of the hills and therefore not in a position to compete successfully.

Owing to the light nature of the Superficial Deposits these soils can be worked with implements in almost any condition of weather; hence the various crops can be sown according to the calendar and the date of maturity forecasted with some degree of certainty in the average of seasons. Such soils, however, 'dry out' in summers of light rainfall, and ground crops suffer from drought.

The rotation includes a wide range of root crops, mangels, swedes, turnips, kale; vetches, wheat, oats and barley are also grown, the latter producing excellent samples.

In the market-gardens, spring cabbages, asparagus, potatoes, peas, lettuces and radishes are grown for early consumption, but the success of strawberries, runner beans, and spring-sown onions is dependent upon a reasonable amount of rain during May and June. Of top fruits, plums (chiefly the Pershore or egg plum) predominate, but apples and pears do well as half standards under cultivation. Gooseberries for early picking are also grown.

In common with light soils of other districts, those of this district are apt to become very weedy; characteristic species are spurrey (*Spergula arvensis*), lesser sour-dock (*Rumex acetosella*), and ephemeral types such as chickweed, speedwells, groundsel and shepherd's purse.

For the improvement and maintenance of soil fertility periodical applications of organic substances are essential, the principal object in view being to increase the retentivity of the soil for water. The best materials are farmyard and stable manures and certain kinds of shoddy; fish, and meat and bone manures are now being more widely used than formerly. Residues of vegetable crops should be ploughed, or dug, in and more use might be made of white mustard as a quick growing plant for green manuring. Even autumn weeds (especially chickweed) have their uses in this respect. Free use of the hoe and other implements for surface working should be made during dry weather; loss of subsoil water by direct evaporation is thus prevented and moisture is conserved to plant roots during critical times.

Periodical applications of lime are necessary as calcium carbonate is quickly leached out by percolating water. Attention to this essential would lessen 'finger and toe' of swedes and 'club root' of cabbages so prevalent on light soils deficient in lime: spurrey would also disappear.

With respect to artificial manuring it should be the aim of the grower to give to temporary and quick-growing crops a complete fertiliser supplying nitrogen, phosphates and potash, not only with a view to obtaining maximum results immediately but also with the object of maintaining soil fertility.

On the North Cotteswolds sheep and the breeding of young stock is the branch of Agriculture principally practised, although wheat is pretty extensively grown on ' the better lands '—that is, brash with the admixture of a little clay. The rotation of crops is—wheat, swedes or turnips (for flocks in winter), barley or oats, rye-grass and clover, and then wheat again. Some fields are laid down to sainfoin for seven or eight years as the crop, if not grazed, makes excellent hay for any kind of stock and is said to be very good for sickly lambs. The pure Cotswold breed of sheep is almost extinct as cross-breeding with Hampshire Downs has been resorted to because the Cotswold breed gave too much coarse fat for the liking of the butchers. The cattle on the hills are principally shorthorns and are the kind that do best. The young stock raised on the hills are generally sold to farmers in the vale for fattening ; but some farms have hill and vale grounds and the two work well together.

The natural pastures on thin soils produce light crops of hay, but when permanent pastures have been established by using suitable ' seeds ' (including especially cocksfoot and perennial rye-grass), heavier crops are obtained and the aftermath grazing is improved. White clover grows freely if encouraged by generous application of phosphatic fertilisers, preferably superphosphate or steamed bone flour, and, under favourable circumstances, it becomes the dominant constituent of the herbage. This propensity may be turned to useful account by grazing the pasture till June and allowing the later prolific crop of flower heads to seed : when carefully harvested and cleaned a ready sale for the seed is obtainable at a remunerative price.

Calcareous pastures tend to be naturally rich in leguminous plants and particularly species of *Vicia* and *Lathyrus* ; salad burnet (*Poterium sanguisorba*) and parsnip (*Peucedanum sativum*) are generally abundant.

The chief physical characteristic of these soils is that they are typically sticky when wet and cake superficially on drying ; they, however, warm quickly in early summer. Their fertility is mainly proportionate to their depth and admixture of brash. Thin soils overlying bed rock ' dry out ' rapidly, hence corn crops are frequently short in length and young swedes suffer severely from attacks of the turnip flea beetle.

Calcareous soils lose organic matter very readily by decay in consequence of the high percentage of carbonate of lime, and as farmyard manure is not an abundant commodity on the upland farms, the practice of folding sheep on swedes is an excellent supplementary method of adding humus. Usually, organic fertilisers

Analyses of Soils from the Evesham District

By Cecil Cooke Duncan, F.I.C., F.C.S., County Analyst, Worcestershire

	'Clay [Lower Lias]'						'Loam [Drift] over clay [L. Lias]	'Sandy [Drift over] clay [Lower Lias]'
Reference: Vol. and page	vii. 21	v. 5	v. 26	vi. 75	vi. 71	vi. 67	vii. 28	ii. 9
Moisture: Original Soil	13	35	15	24·4	24·4	22·6	14·1	3·7
Nitrogen on dry ,, ...	0·3	0·27	0·19	0·17	0·26	0·22	0·36	0·29
Air-dried 'Fine Earth' (1mm. sieve) Moisture	6·5	4·8	4	3·9	7·7	6·6	5·2	3·0
Total Lime as CaO	4·0	6·7		Fe_2O_3 3·5	3·1		1·7	
Carbonates	Large	Large	None	Large	Large	Large	Trace	
Available Plant Food (Dyer) in 'Fine Earth'—								
Potash (K_2O)	0·004	0·003	0·007	0·001	0·002	0·01	0·011	0·011
Phosphoric Acid (P_2O_5)	0·016	0·008	0·05	0·012	0·006	0·007	0·034	0·022
Sodium Chloride (Na Cl)								
Organic matter and combined water ...	3·23	9·05					5·05	7·45
Insoluble matter	66·21						(3·28	81·25
Fe_2O_3 & Al_2O_3	10·98						15·73	8·46
Ca O	4·02	6·72					1·76	0·91
Mg O	0·72						0·93	0·62
P_2O_5	0·15						0·33	0·22
K_2O	0·63						0·44	0·43
Na_2O	—						0·54	
Mn	Trace						Trace	Trace

are too expensive for the class of farming followed especially as haulage through long distances and up steep gradients is such an expensive item. Of the three chief plant foods, potash is frequently deficient : it, is therefore, advisable for the production of satisfactory root crops (swedes) to give a complete artificial fertiliser. Sulphate of ammonia may be freely used as the nitrogenous constituent.

The arable soils are notoriously weedy, two species of geranium, dove's foot crane's bill (*Geranium molle*) and cut-leaved crane's bill (*G. dissectum*), being very troublesome.

In consequence of altitude, exposure, and thin soils the Cotteswold upland is not suitable for commercial fruit growing and market-gardening. But recently, plantations of considerable area have been laid out on the south-west slope of Bredon Hill between 500 and 600 ft. altitude. Some of the plantations are well screened by tall beeches but others are in full exposure. Apples, plums, gooseberries, currants, and strawberries have been planted and the prospects appear to be promising. Some trouble was experienced in the planting of the top fruits as brash had to be removed in preparing the holes.

Trees that grow well on the Cotteswolds are beech, ash, and larch —the last a very useful tree that might be planted more extensively on the poorer ground.

Building Stone

In the vicinities of Bredon, Alderton, and Langley Hills and Burhill, the Lias Marlstone has been used to a small extent for building purposes.

On the hills there is a wealth of good building-stone in the Pea Grit (or its equivalent) and Lower Freestone subdivisions of the Inferior Oolite Series.

The Pea Grit in its lower portion at Cleeve Hill furnishes excellent stone capable of carrying considerable weights : such stone was until recently quarried below the ancient camp on the edge of the hill. Lower Freestone was formerly extensively quarried above Postlip, and 'mined' at a quarry between Whittington and Puckham.

In the main hill-mass of the North Cotteswolds the Pea Grit is represented approximately by the 'Yellow Guiting Stone,' typically of a pleasing warm brown or 'orange' colour as it is called in trade circles ; while the Lower Freestone—known at Temple Guiting as the 'White Guiting Stone'—maintains on the whole the aspect it presents in the Mid Cotteswolds ; but, if anything, in the lower portion it is a little yellower. It is often somewhat difficult to determine precisely where the Pea Grit-equivalent ends and the Lower Freestone commences.

The ' Yellow Stone ' is worked at the present time to a small extent in a portion of the vast Jackdaw Quarry, Stanway ; and at a small quarry called ' Piece Quarry,' at Snowshill. In the past it was extensively worked at the ' Tally Ho ' Quarry, near the Foxhill Inn, ¾-mile south of Guiting Power ; at the ' Yellow Guiting Stone ' Quarry, Temple Guiting ; Coscombe Quarry, between Ford and Stanway ; and at the Bourton Quarries, Bourton on the Hill. Stone of the same age was also once largely quarried at Brockhampton, near Sevenhampton ; and is still to a small extent at Longborough Quarry above Longborough.

The ' White Stone,' becoming yellowish in the lower portion, is worked for building-purposes now only at the quarry south-west of ' The Fish ' on Broadway Hill, and there only to a small extent. In the past, it was worked at a quarry in Oathill Plantation—close to the ' Yellow Stone Quarry,' Temple Guiting ; and ' mined ' at Westington Hill, near Chipping Campden ; and at the ' Tally Ho ' Quarry in Bourton Woods, close to the road from Bourton on the Hill to Blockley.

The ' Tally Ho ' Quarry near the Foxhill Inn and the ' Yellow Guiting Stone ' Quarry, Temple Guiting, were for long worked for the ' Yellow Stone ' by Messrs. Groves Bros. In 1901 The Taynton and Guiting Quarries, Ltd., acquired these two quarries and the ' White Guiting Stone ' Quarry—working this last only when there was a demand for the ' White Stone.' In 1905 the Company closed the ' Tally Ho ' Quarry and removed the plant to the then recently-opened Coscombe Quarry. In 1909 work ceased at the ' Yellow Stone ' Quarry in order to concentrate at Coscombe.

The ' Yellow Guiting Stone ' has no tendency to fade, but rather to attain a warmer shade with age ; Guiting Grange exhibits the colour to perfection. It is a very free-working stone, hardens on exposure, and is not affected by frost—not even when the quarry-sap is still in it. Blocks 6 to 7 ft. in depth and any reasonable size could be obtained, and when freshly drawn averaged 14 cubic ft. to the ton. The mansions, farm-houses, churches, and buildings generally in the neighbourhood are a standing testimonial to the merits of the stone—the sharpness of all angles, and the clean, square and upright appearance of the buildings being particularly noticeable.[1]

H. B. Woodward remarked[2] : ' The Bourton Stone (of Bourton on the Hill) is not considered so good as the Cheltenham or Painswick Stones [Lower Freestone]. It comprises an upper bed of oolite, known as the White Rock [see p. 68], which is used for rough inside walling, and is burnt for lime. The last freestone is the Yellow bed, an oolite, of which blocks about 40 cubic feet in size are sometimes obtained, but those of 10 or 12 feet are the usual size. 16 cubic

[1] See *Proc. Cotteswold Nat. F.C.*, vol. xix, pt. 1, 1915, p. 23.
[2] ' Jurassic Rocks of Britain ' (*Mem. Geol. Surv.*), vol. iv, 1894, p. 476.

feet go to the ton. The Red Bed, a ferruginous and cellular oolitic stone, is used for foundations, but it is a hard rock that " breaks all tools ".'

Tile-stones

Tile-stones occur at two horizons in the district—in the Chipping Norton Limestone and in the Stonesfield Slate Series. In both cases, where stones are found of a suitable thickness, but usually on the thick side, for shaping into tile-stones without being ' frosted ' (see below), they are called ' Presents.'

The Chipping Norton Limestone tile-stones or ' slates ' that were mostly worked were thick and heavy. The principal workings were Hyatt's (or Hyates) Pits, about 1½ miles S.E. by S. of Snowshill, and, along with ' Kineton [or Kyneton] Slates ' (Stonesfield Slates), tile-stones from these pits have been used in the village of Snowshill. There were numerous other workings, however, in the immediate neighbourhood at one time and another as the numerous inequalities in the ground testify and such a name as ' Upper Slate Pits.' Very similar tile-stones could be got, and appear to have been locally to a small extent, in the vicinity of the Buckle Street for a mile or so south of where it crosses the Guiting-Stow road. Rock furnishing less satisfactory tile-stones, but more suitable flagstones, caps a considerable portion of the high ground between Condicote and Copse Hill, Upper Slaughter. ' Tip ' of probably ' Presents ' of old workings may be seen above the present face of Fenwick's Quarry, in Lower Swell parish ; while at Flagstone, about half way between Condicote and Upper Swell, tile-stones and flagstones were quarried and ' mined ' : one ' mine ' runs under the road but the entrance is now blocked up with stones and wire netting.

An interesting feature about the Chipping Norton Limestone tile-stones is that those from this sub-division where it occurs along the northern margin of the Stonesfield Slate tract of Eyford are practically indistinguishable in lithic aspect from the more arenaceous Stonesfield Slates of that tract. The bed yielding them, however, appears to be very thin and it is unlikely that it would pay to work it. Samples of these tile-stones may be seen in a quarry in the northern side of the dry valley ½-mile W. by 5°S. of Kinetonhill Farm, and in the second field to the west of Swell Hill Farm.

Stonesfield ' Slates,' properly tile-stones,[1] have been worked in the district for centuries—at times, of course, more actively than at others. The walling of Belas Knap Tumulus, 1¾ miles S. by 5°W. of Winchcomb, is of this rock, probably of ' Presents,' but beautifully faced.

At the present time the industry is very active and the demand exceeds the output. Quarries or pits are in work on The Downs,

[1] Though called ' slates,' they are tile-stones or thin flagstones only, slaty cleavage being entirely unknown in the Oolites.

A.—THE COTSWOLD SLATE CO.'S PIT, EYFORD HILL. STONESFIELD SLATE SERIES, SLABS LAID CUT FOR FROSTING.

B.—THE COTSWOLD SLATE CO.'S PIT, EYFORD HILL. STONESFIELD SLATE SERIES, SLABS STACKED READY FOR TRANSPORT.

Salperton ; near New Buildings close to the Stow Road above Harford Bridge ; near Huntsman's Barn (Huntsman's Quarry), close to the Buckle Street north-eastwards of Summerhill in Naunton parish ; and at Eyford Hill (Cotswold Slate Company). In times past the ' slates ' have been very extensively worked at and in the vicinities of the localities mentioned, as the old spoil heaps and workings testify—especially to the east of Huntsman's Quarry, on the north side and towards the head of the valley running up from Eyford Park and not inaptly known locally as the ' Valley of Thorns.' In addition, they were extensively worked on and near Sevenhampton Common ; by the side of the ' Bourton road ' north of Folly Farm, near Aston Blank, where the Slate Bed is at present quarried for road-metal ; and, to a small extent, near Hawling. The ' slates ' have sometimes been marketed under the names of the localities at which they were got—for example, ' Kineton [or Kyneton] Slates ' ; but now generally as ' Cotswold Slates.' They are sold by the 1,000 : in 1924 the prices at the Cotswold Slate Company's pits at Eyford Hill were :—Best Quality, per 1,000—£6 7s. 6d. : Second Quality, per 1,000—£5 15s.

Undeveloped ' slate ' exists at and in the vicinities of all the localities mentioned above ; but when selecting a site for opening a quarry care should be exercised for the strata are locally much faulted (and the Slate Bed or Pendle may run out at a fault against other deposits) and the overburden is locally thick. A layer of distinctive *green clay* is usually present lying on the ' Slate ' Bed, and Fullers' Earth clay, which gives rise to ground that cracks noticeably in dry weather and is spongy in wet, and throws out springs, is not far below.

The ' Slate ' Bed proper or Pendle is very persistent in the district indicated by the localities cited above : the position of the best ' slate ' (which is usually in a bed about 1 ft. thick) may vary within the limits of say 4 ft. ; but that is about all. It has been remarked in literature that the ' slate ' occurs at slightly different horizons ; but this observation may have originated owing to ' Presents ' of other horizons having been thought to have come from the ' Slate ' Beds proper or Pendle.

In the Eyford district the ' slate ' is raised in the autumn, laid on the ground ' with the best side downwards,' and left for ' frosting ' from November until March or April. After ' frosting ' the stones can be at any time readily split into layers sufficiently thin for ' slates.' In the summer, the slatters prepare the ' slates ' : they shape the ' slate ' by placing its edge on a cutting-edge (fixed in a wood-block) and striking off the pieces—so as to get a straight edge —with a slatter's hammer ; and make the hole through which is to pass the peg or nail that holds the slate in position on the roof with a little pick. The slatters are kept on all the year round as theirs is a skilled trade ; but the services of the ' getters ' are temporarily disposed of when not required. As already mentioned there is a

large demand for the ' slates ' : it is said from all over the country. The supply is inadequate to meet the demand. The reason given is that there are not enough slatters and few young ones coming on.

Concerning the getting and preparation of the ' slates ' at Stonesfield in Oxfordshire, H. B. Woodward observed[1] : " The blocks of fissile oolite, fine-grained calcareous sandstone with courses of oolite, and calcareous sandstone, when dug out, must be kept damp, and then exposed to a winter's frost. After that they can be split up evenly at any subsequent time. If they have been allowed to dry, so that the " sap " is dried up, no frost will move the layers, and the rock is then " bound." Formerly it was the custom to begin digging the stone about Michaelmas time or before ; now the men commence about the end of October, and work till the end of January. When dug and raised, the stone is banked up and covered with earth, to keep the moisture in, until a frost comes. In dry seasons, the quarrymen even water the blocks to keep them moist. It requires three or four good frosts to act upon the stone. . . . As a rule a week's frost is needed."

" Deal pegs are used for fixing the slates. Oak pegs were formerly used, but it is found that deal forms a better head when driven in than oak, and not so many slates are broken. Copper and iron nails have also been used."

Bricks, Tiles and Pottery

At the present time (1925) there are four brickworks ' in work ' in the district :—the Battledown Brickworks (Messrs. Webb Bros., Ltd.) (see p. 12) ; the Winchcomb Brick and Tile Works, Greet, near Winchcomb (p. 15) ; Capt. E. G. Spencer Churchhill's brickworks near the Station, Blockley (p. 15) ; and the Aston Magna Brick and Terra-Cotta Works (p. 15). The clay used at all four is Lower Lias clay.

Within the Borough of Cheltenham the only brickworks now ' in work ' is the Battledown Brickworks, but in times past they were very numerous. Particulars of many of these former works and of the Battledown and Aston Magna Works are given in the paper on ' Brickearths, Pottery and Brickmaking,' by the writer and R. J. Webb.[2] At Broadwell, near Stow on the Wold, bricks were at one time made from Upper Lias clay.

At the Cotteswold Potteries, Ltd., Leckhampton, Cheltenham, flower-pots principally, but also many other varieties of horticultural and other ware—from table knick-knacks to rustic stumps and garden vases, were made.[3] At Greet, near Winchcomb, there was formerly ' Beckett's Greet Pottery.'[4]

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[1] ' Jurassic Rocks of Britain ' (*Mem. Geol. Surv.*), vol. iv, 1894, pp. 484, 485.

[2] *Proc. Cheltenham Nat. Sci. Soc.*, n.s., vol. i, pt. 4, 1910, pp. 260-277 ; see also Richardson, L., *Proc. Cotteswold Nat. F.C.*, vol. xvii, pt. 3 (1912), p. 302.

[3] *Idem*, pp. 263, 264.

[4] *Idem*, pp. 273, 274.

There is, of course, abundant material in the district in the form of Lower Lias clay for brick making; but, by itself, the clay is too 'strong' to make good bricks and it is therefore advisable (if possible) to grind up sand or breeze with it. The same remark would apply to the Upper Lias clay.

Sand

In the vale west of the hills the Superficial Deposits at many localities provide an abundance of sand for building and general purposes. The principal localities at which it occurs are:—Cheltenham (for example, at the Battledown Brickworks); Bishop's Cleeve; Gotherington; Alstone; Alderton; Little Washbourne; Great Washbourne; Beckford; between Aston Somerville and Wormington; Childs Wickham.

There is no sand in the Vale of Bourton.

The Harford Sands (Inferior Oolite) cover a considerable part of Cleeve Hill. "It is reported that they were dug for use in the Staffordshire potteries, and that they were conveyed thither upon the backs of donkeys. The presence of the sand is often indicated by gorse-bushes."[1]

They are used in the polishing-process in certain of the sculptors' works at Cheltenham: ". . . the sequence after the use of the chisel being (*a*) Charlton Kings sand [Superficial Deposit], (*b*) Cleeve Hill [Harford] sand, (*c*) "grit", (*d*) "bilsom," (*e*) Gorsley [Downton Castle Sandstone—Silurian], (*f*) "Snake," and (*g*) putty powder, *plus* oxalic acid, *plus* salts of lemon; but from outdoor work they leave off at Cleeve Hill sand."[2]

Harford Sands are dug half-a-mile east-north-eastward of Snowshill and on the edge of Bourton on the Hill Downs west of Bourton Hill House. As will be gathered from a perusal of the account of the Harford Sands given on page 38 there are a number of other localities at which they could be worked if required.

Lime

The Lower Freestone is burned for lime $\frac{1}{3}$-mile N.E. by N. of Northwick Hill, Blockley; at a quarry some 700 yds. S.E. by S. of Wagborough Bush, Upper Slaughter (by W. Cox Howman, Builder, Stow on the Wold and Bourton on the Water); and occasionally at a quarry $\frac{1}{2}$-mile N.E. by E. of Seven Wells, Broadway parish. Chipping Norton Limestone is burned for lime at a quarry (W. Cox Howman) to the west of the road from Stow on the Wold Station to the town—about half-way up the hill; and was so formerly at Flagstone between Upper Swell and Condicote. A sample of

[1] Buckman, S. S., 'Deposits of the Bajocian Age in the Northern Cotteswolds: The Cleeve Hill Plateau,' *Quart. Journ. Geol. Soc.*, vol. liii, 1897, p. 611.

[2] Richardson, L., '[Excursion to] Cleeve Hill,' *Proc. Cheltenham Nat. Sci. Soc.*, n.s., vol. i, pt. 4, 1910, p. 286.

Chipping Norton Limestone from Guitinghill Quarry has been analysed (18.8. '28) by R. Sutcliffe, and lime (CaO) was found to be 52.09 per cent.

Clay

Snowshill Clay is dug for puddling dew-ponds, etc., by the side of the Buckle Street some 500 yds. S. by E. of Broadway Tower, and at Snowshill Hill. As will be seen from the account of the Clay given on page 39 there are a number of other localities at which it could be dug if desired.

In times past there were many old-fashioned dew-ponds on the hills and their construction was a full-time occupation for two men living at Aston Blank. At the present time there is a revival in the construction of dew-ponds for cattle in the North Cotteswolds where water is not laid on to the fields, but the puddle is overlaid with a layer of cement or concrete.

Road Metal

As in other parts, the highroads in this district are being re-metalled with imported stone and tar. So are the majority of the by-roads in the vale; but in the hill-country they mostly continue to be maintained with local stone.

In times past the Marlstone of the Middle Lias was actively quarried above Ashton under Hill and Gretton, on Alderton Hill and Burhill (above Buckland) for use on the roads in the vale, but now all the quarries are abandoned.

On the hills all the Ragstone Beds of the Inferior Oolite and the Chipping Norton Limestone have been worked at one time or another for road-metal, but now, with few exceptions, the quarries are in Notgrove Freestone and Chipping Norton Limestone. The exceptions are—the Gryphite Grit worked at the quarry in the angle made by the Five Mile Drive and road to Blockley; and the Clypeus Grit worked in quarries (*a*) east of Little Rissington and (*b*) near the lodge for Gawcombe, south of Church Iccomb. The Notgrove Freestone makes a very fair road metal for by-roads, and is worked at the present time:—a little less than 1 mile E.N.E. of Snowshill; a little to the south-westward of Fordhill Barn, Temple Guiting; $\frac{1}{4}$-mile westward and $\frac{1}{2}$-mile southward of Farmcote Wood Farm; and by the road-side at Lonehill Wood, Spoonley, near Winchcomb. In Roel parish it occurs at or near the surface over a considerable tract and masses of its 'Bored Bed' are seen as 'toppers' for many of the field-walls. The Chipping Norton Limestone, at most localities, makes a more durable road-metal than the Notgrove Freestone, and is worked at the present time for this purpose:—about $\frac{1}{4}$-mile southward of Smallthorns, Snowshill; 1 mile to the west of Bourton on the Hill; Guitinghill Quarry, 1 mile westwards of Condicote;

Newpark Quarry, Longborough, ¼-mile E. of Bembro, Temple Guiting; Bolton's Ground Quarry, near Fox Farm, near Condicote; in a field on the west side of the Moreton road, 1 mile north of Stow on the Wold; Granny's Bank Quarry, between Lower Swell and Eyford; and near Combehillhead Rookery, ½-mile west of Upper Harford, Naunton. Speaking approximately, the Chipping Norton Limestone is the local rock mainly used for metalling the by-roads to the east of a line drawn from Broadway Tower to Naunton; the Notgrove Freestone, to the west thereof.

At a quarry in a field adjoining Stanborough Lane or the Bourton on the Water road N.E. by N. of Pemmington Coppice, Notgrove parish, the Pendle or Slate Bed of the Stonesfield Slate Series is worked for road metal, although from the overburden of old spoil tips it is obvious that it was once excavated for 'slates.' At The Downs Quarry—No. 2, Salperton, the bed above the Slate Bed is used for road metal, and so are the Flagstones at the Huntsman's Quarry, near Summerhill, Naunton.

WATER[1]

Water is to be met with at six geologic horizons in the rocks of the country dealt with in this memoir, namely: (1) In the Superficial Deposits; (2) at or near the base of the Sandy Beds of the Middle Lias; (3) at the base of the thin Cotteswold Sands, or, where they are absent, at that of the Inferior Oolite from which the water is thrown out by the underlying Upper Lias clay; (4) on top of the Snowshill Clay, in the Inferior Oolite Series; (5) at the base of the Stonesfield Slate Series, from which the water is thrown out by the underlying Fullers' Earth; (6) at the top of the Marly Beds in the Upper Division of the Great Oolite.

Superficial Deposits.—The Superficial Deposits—sand, gravel, etc.—occur almost solely on the surface of the Lower Lias of the Vales of Bourton on the Water, Moreton, and Evesham. The Lower Lias is a notoriously bad formation in which to seek water, and if it had not been for the sporadic occurrence of Superficial Deposits its extensive outcrop area would have been practically destitute of large villages—except close under the hill sides where supplies could be drawn from streamlets originating mostly in springs thrown out by the Upper Lias clay. As it is, it is noteworthy that practically every village in the vale away from the foot of the hills, is, in part or whole, on Superficial Deposits. In some cases owing to the lack of care in the matter of sewage-disposal, in others to extensions of villages on to the Lias clay; in yet others to the two causes combined; it has become necessary to seek sources of supply further afield resulting in the installation of piped services. Alderton still depends on wells, up to 15 ft. in depth, in a sand-bed; and

[1] Further information will be found in a forthcoming memoir on the Wells and Springs of Gloucestershire.

Bourton on the Water on some two hundred wells in a gravel (Oolite) bed ; but in every other village there is a piped service supplying some or all the houses with source of supply springs in the neighbouring hills. An important and admirably conceived scheme that serves a number of villages in the Vale of Evesham is that of the Evesham and Pebworth Joint Water Committee with principal source springs thrown out by the Upper Lias in Lidcombe Wood, Stanway. Moreton in Marsh—on gravel—is supplied from a spring in the valley of the River Dikler near Swell Mill, Upper Swell.

Locally, as by the side of the road about halfway between Bishop's Cleeve and Gotherington, and at the back of Great Washbourne Cottages in the village of Great Washbourne, some very useful springs issue from the Superficial Deposits, and experience indicates that although their yield may fall off in and following periods of drought they rarely fail. Also, some very useful supplies are obtainable for limited requirements : for example, Cleeve Grange, Bishop's Cleeve, has water raised to it by a windpump from two large shallow wells in gravel near by.

The water from the Superficial Deposits is on the hard side, and is often found to have saline ingredients derived from the surface of the subjacent water-upholding Lower Lias clay.

Wells sunken into the Lower Lias are unlikely to yield adequate supplies of water all the year round and are always liable to tap saline water. The ' Cheltenham Waters ' are derived from the Lower Lias by means of dug wells. The exceptions are often those that luckily pierce a limestone-band or cut a vein or pocket of sand and/or gravel (Superficial Deposits). In dry periods the clay ground cracks badly and then—more particularly if the well has not been properly constructed, pollution from the surface is likely to be effected by way of the cracks. Salt-water pools are occasionally to be found on the surface of the Lias clay—for example, on Lower Stanley Farm, Alderton.

Borings into the Lower Lias in search of water are not likely to be successful. Nor should the idea of boring through the Lower Lias to the next water-containing formation—the Lower Keuper Sandstone, be entertained without realization of what such a project means : in this district it would probably mean boring through up to 1,005 ft. of Lower Lias and Rhaetic, and from 481 to ? 700 feet of Upper Keuper Marl, and then the water tapped might be too hard and/or saline for ordinary domestic purposes and diminish in yield if pumping exceeded the natural recharge.

Middle Lias.—The springs from at or near the base of the Sandy Beds of the Middle Lias are small. The base of the Sandy Beds comes at or near where the ground of the vale commences to rise into the hill-slope and can be readily detected by the outburst of water either in the form of small springs or a mere effluent seepage giving

rise to spongy ground. The springs from this horizon are small because the outcrop—'intake'—of the Sandy Beds is narrow; the dip of the beds—except in the Alderton-Dumbleton 'outlier'—is *into* the hills, and therefore the capacity of the Beds is soon satisfied. In dry periods the yield of the springs is likely to soon fall off.

A number of villages, in part or whole, have piped supplies from Middle Lias springs—Ashton under Hill, Bishop's Cleeve, Dumbleton, Great Washbourne, Little Washbourne, and Broadwell, near Stow on the Wold.

Water from the Middle Lias is frequently irony; irony or chalybeate waters have been observed at Prestbury (about 200 yds. east of Noverton Mill, which had a local reputation of being 'good for the eyes'); up the combe east of Woodmancote, Bishop's Cleeve; at Wolston (pump); Dumbleton (one of the springs contributing to the village supply, the water of which has therefore to be filtered through gravel); at Blockley ('at the lower end of Westmacott's Lane,' and in the 'drying yard'[1]); up Shoals Lane, Batsford; and at the long-abandoned 'Stow Spa,'[2] between Lower Swell and Stow on the Wold. A chalybeate water is beneficial in cases of anaemia, but its customary use is provocative of constipation and, some say, of goitre.

Inferior Oolite.—At the base of the Cotteswold Sands, or where they are absent, at that of the Inferior Oolite, is the most important geologic horizon at which springs issue in this district.

The structure of the main hill-mass of the North Cotteswolds is roughly synclinal, or perhaps better, the northern portion of an ellipsoidal basin. The water that falls as rain therefore—except on and close to the edge of the hills and where there are faults near the edge—travels inwards. It is ultimately carried off by the River Windrush, and is collected by that river and its tributaries the Rivers Dikler and Eye, and the Sherborne Brook.

The structure of the Cleeve Hill mass—a detached portion of the North Cotteswolds—is also roughly synclinal with an axis pitching south-eastwards. The drainage of considerable portions of it emerges at the Puckham Farm and Syreford Springs and finds its way into the River Coln—also a Thames-System stream.

The outflow of the small springs on the slopes of the hills bordering the Moreton Valley to the south of Moreton in Marsh, is carried off by the slow-moving Evenlode into the Thames; but that of those

[1] 'The History of Blockley in the County of Worcester,' compiled by the Rev. Alfred J. Soden, 1875, p. 4. The spring 'at the lower end of Westmacott's Lane [now taken into Blockley Court grounds]' was built over when Soden wrote—? by Westmacott's Mill. The 'drying yard' has been taken into the grounds of the Manor House and the 'spring' (well) is hidden by laurels on the right-hand side on entering the Manor House grounds.

[2] Richardson, L., '[Excursion to] Eyford Park . . .', *Proc. Cotteswold Nat. F.C.*, vol. xxi, pt. for 1922 (1923), pp. 75, 76.

to the north in the vicinity of Blockley, round by Broadway to Charlton Abbotts, round the Cleeve Hill mass, *via* Gretton, Prestbury and up the Chelt Valley to Dowdeswell, by Severn tributaries.

Slips of Inferior Oolite limestone on the Upper Lias clay slopes are frequent on the hill-sides and therefore the first appearance of springs is often at a lower altitude than that of the true geologic horizon at which they issue.

The strongest springs issuing from the hill-sides are those up Dovedale, Blockley (drawn on for the supply of Blockley) ; Middle Hill, Broadway (Evesham Supply) ; at Lidcombe Wood, Stanway (Evesham and Pebworth Joint Water Committee ; Cutsdean and Ford) ; and at Corndean and Postlip in the north-eastern portion of the Cleeve Hill mass. One of the sources of supply to Cheltenham is a reservoir impounding the head-waters of the Chelt at Dowdeswell.

From smaller springs there are piped services to Iccomb, Batsford, Chipping Camden, Saintbury, Willersey, Broadway, Buckland, Laverton, Stanton, Stanway, and Winchcomb (St. Kenelm's Well, etc.). Hailes and Toddington are supplied from a well through Cotteswold Sands to Upper Lias clay at Lyne's Barn, Pinnock, just over the edge of the hills within the Thames basin, from which the water is syphoned over the ' divide.' The supply for Stow on the Wold is obtained from the ' District Well ' (Stow on the Wold Urban District Council), which is 130 ft. deep (through Oolite and a trace of Cotteswold Sands to Upper Lias clay), has from 6 to 15 ft. of water in it, and gives an average yield of 20,000 gallons per day. For long the chief source of supply to the town was ' Stow Well '—a spring thrown out by the Upper Lias clay—by the side of the Broadwell road.

Within the main hill tract of the North Cotteswolds springs are to be met with in those portions of the valleys in which Upper Lias clay is exposed in the bottoms. Water is taken from the majority of these springs, for village and farm supplies : for example, springs in Wells' Head Bottom for Temple Guiting ; Joe's Hole Spring, close to the Windrush, for Kineton ; Slade Barn or Bradwells Head Spring for Hyde Farm ; Broadwater Spring for New Barn Farm, Temple Guiting ; below Guiting Power for that village ; at Naunton for the village ; Seven Springs, near Harford Bridge for Upper Slaughter ; and Milton's Well, Eyford Park, for the Park and Eyford Hill.

Owing to the roughly synclinal structure of the North Cotteswolds and faulting, whereby permeable Cotteswold Sands (thin) and Inferior Oolite have to be traversed by the streams, much of the drainage is subterranean : it is not until the main outcrop of the Upper Lias clay is encountered in the vicinity of the Vale of Bourton that the product of that drainage appears in force in fast-flowing streams. Thus the drainage is mostly underground—of the River Dikler above Waterhead Barn ; of the River Eye above the Roaring Wells in Eyford Park (above which are some very impressive dry

valleys) ; and of the Sherborne Brook above (near) Farmington. Portions of the valleys of these streams, normally dry, become occupied by streams when the water-table rises following rainy periods, and streams flow all the way down the valleys. In the valley of the Sherborne Brook in the vicinity of Turkdean in olden days the stream-course was puddled to retain the water over the permeable rocks ; but loss of recollection of the fact resulted in the ditchers cleaning out the puddle with consequent damage to the water-retaining capacity of the channel.

	Area of Whole Basin (In square miles)	Area of Basin down to appearance of permanent spring and stream (In square miles)
River Dikler	22·00	13·25
River Eye	11·75	7·25
River Windrush (to Great Barrington)	29·00	23·00
Sherborne Brook	22·50	20·00

In the Inferior Oolite Series of the North Cotteswolds, between the Harford Sands and Ragstones, is a bed of clay known as the Snowshill Clay. It is an important water-upholding deposit coming as it does amid a thick mass of permeable Inferior Oolite. If it had not been for its occurrence water would have been scarce indeed in the heart of the North Cotteswolds, and obtainable on the spot only by means of very deep wells.

Springs are thrown out by the Snowshill Clay :—

1.—(Probably by this Clay) in the field north of Notgrove Station, the water of which is collected and piped to a standpipe by the road-side immediately north of the Station ;

2.—On the hill side W.S.W. of Ford (Temple Guiting), the water of which is collected into a reservoir and piped (gravitation) to supply Ford ;

3.—At Seven Wells (*olim* Starveall Farm), the principal of which springs runs into a pond, the overflow of which sinks into Harford Sands ;

4.—Near Heath Farm (close to Seven Wells), the water of which is collected in a reservoir and piped to supply the farm ;

5.—In the ground close to the lodges ¼-mile north of Springhill, the water of which is piped to a tap near, and for the use of, the Lodges ;

6.—In the grounds of Springhill (below the house), the water of which courses down the valley-side through Hare Wood and sinks into ' Cotteswold Sands ' in the valley bottom ;

7.—In a field, close to the road-side, a little before reaching Westington Hill Quarry from the Broadway—Stow on the Wold road, which maintains a small pond, and in the vicinity of which there are ample indications of the Clay ;

8.—At Northwick Hill, Blockley, to the west of which, on the Clay, is a withy-bed ;

9.—At ' Nether ' Upton Wold, which was once used for the domestic supply ;

10.—On the valley-side facing ' Far ' Upton Wold, below the level of the outburst of which is ample evidence of yellowish freestone ;

11.—At Upton Wold Cottages, where the spring maintains a shallow circular dip protected by a circular wall ;

12.—In the wood immediately north of ' Far ' Upton Wood, where they are strong, deposit carbonate of lime (tufa), and the water of one of them is raised by ram to supply the house ;

13.—At ½-mile N.E. by E. of Bourton Hill House ;

14.—At Sezincote Hill, where a spring—which maintains a pond, the overflow of which sinks into the ground—has been tapped above its outburst by a shallow well, surmounted by a windpump, for the supply of the house (see also p. 72) ;

15.—On the valley-side W.S.W. of the lodge (south of ' Far ' Upton Wold) for Springhill ;

16. Close to the cottage some 700 yds. W. by 12°N. of that lodge, the water of which courses down the valley side for a short distance and then sinks in. Locally the water is considered to be ' good ' for the eyes ;

17.—Some 300 yds. S.S.W. of Springhill ;

18.—Some 300 yds. S.W. by W. of Springhill, the water of which is collected in a feed tank from which it gravitates to a ram at the barn which forces it up to Snowshill Hill ;

19.—Between Smallthorns and Snowshill Hill, the water of which is piped to Horn's Leazor, the overflow going into the pond, and thence into the ground ;

20.—At Snowshill Hill ;

21.—Some 220 yds. S. by W. of Scarborough, the water of which is piped to a tank at Scarborough, from which that farm and Cutsdean Lodge are supplied ;

22.—Some 750 yds. N. by E. of Trafalgar, where there is a collecting tank (below ground level), from which Guitinghill Farm is supplied ;

23.—Close to the last, the water of which is piped to a windpump about 150 yds. east of Trafalgar that raises it to a reservoir near the cottages and farm-buildings for the supply of the estate ;

24.—Down the valley east of Trafalgar, where the waters of two springs are conserved in a large cement-bottomed impounding pond.

25.—At the cottage just north of Puckham Farm, ' and the water from this spring is taken to the farm itself, although that farm is situated not very far above " Upper Lias " ' [1] ;

26.—At the gamekeeper's cottage immediately west of Puckham Wood [2]

27.—At Wontley Farm, where ' it furnishes the sole water-supply.' [3]

Wells tapping water held up by the Snowshill Clay are at: Meadows' Barn, two-thirds of a mile E. by 5°S. of Broadway Tower; Northwick Hill, Blockley; The lodge at the turning to Blockley from the Five Mile Drive; Bourton Hill Farm (p. 71); and Smallthorns (p. 71).

Although the Snowshill Clay does attain locally to a greater thickness, it is unsafe to assume that it is more than a foot or two thick, which means that the sinking of a well should be stopped when the clay is reached and in opening up a spring the clay should not be much disturbed ; otherwise, if the clay is pierced, the water may be lost. Down the valley east of Trafalgar are two springs, the

[1] *Quart. Journ. Geol. Soc.*, vol. liii, 1897, p. 625.
[2] *Idem.*
[3] *Idem.*

water of which is conserved in a cement-bottomed pond. A farm-hand said (April, 1925) that he had recently opened up one of the springs ; that the (Snowshill) clay was from 2 to 3 ft. thick ; that below was (Harford) sand and rock ; and that he had put his hand down fissures as far as he could reach.

Great Oolite.—The areas occupied by the Great Oolite (including the Stonesfield Slate Series at the base) and underlying Fullers' Earth (including the Upper Estuarine Clay at its base), which holds up or throws out the water from the Great Oolite, in the district dealt with in this memoir are small. Numerous small springs, however, occur, and certain are made use of for supplies—at Chalk Hill (the best in the district) for Swell Wold Farm, and, *en route*, a house at Chalk Hill and (by a road-side tap) Swell Wold Cottages ; at Great Hill for Notgrove Station ; the Hay Springs (by ram) for Salperton Park and village ; at Hampen for Hampen House and Lower Hampen ; at Hawling ; Aylworth ; Whitefurlong Spring (by ram to water-tower) for Aston Blank ; at the north end of Notgrove village (dip well and trough) ; in the ground known as " Brash Hailes " (raised by windpump to the reservoir north of Quarry Barn) to supplement the Notgrove supply.

Water from a number of springs from this horizon after or shortly after it has traversed the outcrop of the Fullers' Earth—as at the bog (well-known to botanists) on Sevenhampton Common ; in the vicinity of Chalk Hill, etc.—sinks into the permeable Inferior Oolite.

The water is rather hard—perhaps not so hard as might be expected—and locally soon makes deposit of calcium carbonate ; but the springs, even if the yield falls off, have a reputation for being very persistent. If it is desired to raise the water of any of these springs by ram it is often safer to have two small rams rather than one large one to work which there may be temporarily an insufficiency of water.

The Marly Beds of the Great Oolite Series locally throw out or hold up water (see p. 117).

APPENDIX

List of Geological Survey Photographs in Sheet 217

Copies of these photographs are deposited for public reference in the library of the Geological Survey, Jermyn Street, London. Prints and lantern slides are supplied at a fixed tariff on application to the Director.

Registered Number

4220.—Sand-pit, about ¼-mile south of Stretton on Fosse Church. Glacial Sand and Gravel.

4221.—Ditto. Close view of pit-face, showing current-bedding.

4222.—Pit at Black Downs, 1 mile west of Stretton on Fosse Church. Boulder Clay.

4223.—Great Wolford gravel-pit, about 2½ miles north-east of Moreton in Marsh Church. Glacial Gravel resting on gravel of local origin.

4224.—Ditto. General view of section.

4225.—Gravel-pit, about ¾-mile north-east of Moreton in Marsh Church. Glacial Gravel.

4226.—Westington Hill Quarry, 1½-miles south-west of Broad Campden. Oolite Marl on Lower Freestone.

4227.—Ditto. Close view of quarry-face.

4228.—Holt Quarry, 1 mile west of Blockley. Lower part of the Tilestone, locally sandy, resting on Snowshill Clay.

4229.—The ' hollow '—in the drainage basin of the River Dikler, a tributary of the Thames—in the North Cotteswolds, viewed from ' The Monument,' Broadway Hill.

4230.—Five-mile Drive Quarry, 1¾ miles west of Blockley. Buckmani Grit resting on the Tilestone.

4231.—Oat Hill Quarry, about ⅛ mile south-east of Snowshill Church. Notgrove Freestone.

4232.—Coscombe Quarry, just south-east of Stumps Cross, about 1½ miles S.E. by S. of Stanway Church. Freestone (" Yellow Guiting Stone ").

4233.—Jackdaw Quarry, east of road, about 1½ miles S.E. by S. of Stanway Church. Massive " Yellow Guiting Stone " beneath Lower Freestone.

4234.—Ditto. Another view.

4235.—Yellow Guiting Stone Quarry, about 1 mile north-east of Temple Guiting Church.

4236.—Ditto. Another view.

4237.—White Guiting Stone Quarry, in a wood about 1 mile north-east of Temple Guiting Church. Lower Freestone.

4238.—Guitinghill Quarry, east of road, 1 mile W. by N. of Condicote Church. Chipping Norton Limestone.

4239.—Ditto. Close view of quarry-face.

4240.—Dry valley of the River Dikler, looking S.E. from Hinchwick.

4241.—New Park Quarry, 1 mile S. by W. of Longborough Church. Chipping Norton Limestone.

4242.—River Dikler Valley. Hinchwick Pools.

Registered
Number

4243.—River Dikler valley. Meandering valley, incised through Inferior Oolite limestone to Upper Lias clay.

4244.—Bolton's Ground quarry, about ¾-mile S. by W. of Condicote Church. Chipping Norton Limestone.

4245.— A fault valley, about ½-mile north-west of Chalk Hill, 2 miles south-west of Condicote.

4246.—The Cotswold Slate Company's pit, Eyford Hill. Stonesfield Slate Series.

4247.—Ditto. Close view of quarry-face.

4248.—Ditto. Slabs laid out for ' frosting.'

4249.—Ditto. Slabs stacked ready for transport.

4250.—Ditto. Roofing tiles, stacked.

4251.—Meanders of River Windrush below Naunton.

4252.—Broadway Gravel Pits, about ½-mile north-west of Broadway Church. Limestone river-gravels of Vale of Evesham.

4253.—Ditto. Close view of pit-face.

4254.—Beckford Sand and Gravel Pit, about ¼-mile E. by N. of Beckford Church. River Gravel.

4255.—Ditto. Close view of pit-face.

4256.—Outliers of the Cotteswolds—Oxenton Hill (capped with Marlstone) and Woolstone (or Crane) Hill (capped with Inferior Oolite). Viewpoint: road ½-mile west of Teddington Hands.

4257.—Ditto. View slightly extended eastwards.

4258.—Outliers of the Cotteswolds—Dixton, Woolstone (part), Bredon (part), and Alderton Hills. Viewpoint: about ¼-mile east of Prescott House, 1½ miles east of Gatherington.

4259.—Outliers of the Cotteswolds—Dixton and Alderton Hills. Viewpoint: as in 4258.

4260.—Outliers of the Cotteswolds—Alderton Hill. Viewpoint: field ½-mile west of Stanley Pontlarge.

4261.—Cleeve Cloud—the highest point (1,070 ft.) of the Cotteswolds—from the Vale.

4262.—Exposure on Cleeve Cloud (southern end, western side), 3 miles W.S.W. of Winchcomb. Lower Freestone and Pea Grit Series.

4263.—Ditto. Close view of part of exposure.

4264.—Ditto. Close view of another part of exposure.

4265.—Ditto.

4266.—Cleeve Cloud (western face). Exposure of Inferior Oolite.

4267.—Ditto. Close view, showing slipped masses of Inferior Oolite resting on Lias Clay.

4268.—Ditto. Lower Freestone and Pea Grit Series.

4269.—Quarry, Cleeve Cloud, about 2½ miles W.S.W. of Winchcomb. Lower Freestone.

4270.—Ditto. Close view showing fissures due to movement on Upper Lias clay.

4271.—Gravel-pit, on spur of Cleeve Cloud, ½-mile S. by W. of Postlip Hall. Sludge gravel, or ' Coombe Deposit.'

4272.—Sand Hole, Cleeve Hill, 200 yds. north of clump of small trees, about 3 miles W.S.W. of Winchcomb. Lower Trigonia Grit, Snowshill Clay, and Harford Sands.

4273.—Noverton Gravel-pit, about ½-mile north-east of Prestbury Church. Downwash gravel.

Registered
Number

4274.—Battledown Brickworks, Cheltenham. Lower Lias

4275.—Ditto. Another view.

4276.—Railway cutting between Leckhampton and Charlton Kings stations. Cheltenham Sands on Lower Lias.

4277.—Ditto. Close view, showing even bedding.

4278.—Ditto. Showing constituent pebbles.

4279.—Ditto. A more detailed view.

4280.—Pit, north of road to Whittington, $\frac{1}{8}$-mile north of Syreford. Sludge gravel, or ' Coombe Deposit.'

4281.—Gravel-pit, just east of Mill, Syreford, Downwash gravel.

4282.—Hawling track Quarry, near Guiting Wood, 1 mile north of Roel Hill, about $2\frac{1}{2}$ miles south-east of Winchcomb. Upper Trigonia Grit and Notgrove Freestone.

4283.—Railway cutting (1st) east of Notgrove Station. Harford Sand, Upper Freestone, and Oolite Marl.

4284.—Railway cutting (1st) east of Notgrove Station. Notgrove Freestone faulted against Oolite Marl.

4285.—Ditto. Gently-folded beds of Oolite Marl.

4286.—Ditto. Close view.

4603.—Bolton's Ground Quarry, near Condicote. Upper Estuarine Clay, Viviparus Marl (Neaeran Beds), and Chipping Norton Limestone.

INDEX

(See also Contents, p. iv.)

Agriculture, 137-142.
Alderton, 24; Lower Lias, 14; Marlstone, 23, 24, 26; Upper Lias, 31, 32.
Alluvium, 135.
Alstone, superficial, 123.
Ammonite faunas, Lower Lias, table facing 11; Middle Lias, 24; Upper Lias, 29.
Andoversford, 30, 74.
Annis, L. G., 89.
Arkell, R. S., 100.
Armscott boring, 7.
Ashton under Hill, Marlstone, 23, 24, 27.
Aston Blank, 110.
—— Farm cutting, 80.
—— Magna, Lower Lias, 11, 15; Middle Lias, 23; Glacial, 131.

Banbury and Cheltenham Railway sections, 74-82.
Barton, 116.
' Batsford ' boring, 6, 9.
Battledown Brick Works, 11, 12; superficial, 124.
Bayliss Hill cutting, 18, 19-21, 23.
Beckford, superficial, 33, 125, 126, 128.
Bevan's Quarry, 86, 91.
Bishop's Cleeve, 14; cutting, 21; superficial, 123, 124.
Black Downs, superficial, 130-132.
Blockley, Lower Lias, 11, 15; Middle Lias, 25; Inferior Oolite, 65-68; superficial, 132.
Bolton's Ground Quarry, 86, 94, 99; superficial, 134.
Borings, Armscott, 7; Lower Lemington (Batsford), 6, 9; Mickleton, 7, 9.
Boulder Clay, 121, 125, 128-134.
Bourguetia and Phillipsiana Beds, 43.
Bourton Downs, 70.
—— Hill Farm, 89.
—— Vale of, 7.
—— on the Hill, Inferior Oolite, 68, 69, 86, 89.
—— on the Water, 78-82; superficial, 132, 133
Bredon Hill, Marlstone, 24; Upper Lias, 27, 30, 33; Inferior Oolite, 44, 45, 54.
Bricks, 146, 147.
Brick Works, Aston Magna, 11, 15, 23, 131; Battledown, 11, 12, 124; Blockley, 11, 15; Folly Lane, 14, 20; Greet, 11, 15.
Broadwater, 31.
Broadway, cutting, 19-21, 23, 24; Inferior Oolite, 63; superficial, 121, 123, 125, 126.
Brockhampton, 54.
Brodie, Rev. P. B., 106.
Buckmani Grit, 41.
Buckman, J., 106.
Buckman, S. S., 11, 16-20, 24, 28, 32, 33, 45, 50, 52, 53, 55-58, 62-65, 68, 69, 74-82, 90, 91, 100, 112, 113, 119.
Building Stone, 142-144.
Burhill, 24.

Carpenter, P. H., 110.
Carrant Brook, 125, 128.
Chalk Hill, 113.
Charlton Kings, superficial, 123-125.
Chelt, River, 5.
Cheltenham, 2; Lower Lias, 21-23; Sands, 121-125, 128, composition of, 124, 125, organic remains, 125.
Cheltenham-Honeybourne Railway, Lower Lias, 16-23.
Childs Wickham, superficial, 125, 126.
Chipping Campden, Marlstone, 23.
—— Norton Limestone, 52, 53, 60-62, 69-71, 73, 82-98, 110, 112, 113, 117.
Clay for puddling, etc., 148.
Cleeve Hill, Marlstone, 23, 25; Upper Lias, 30, 31; Inferior Oolite, 45-52; Coombe Deposit, 135; Syncline, 8, 35.
Clypeus Grit, 44.
Coal Measures, 6, 9.
Coltham Fields, 12.
Concealed rocks, 6.
Condicote, Inferior Oolite, 71; Chipping Norton Limestone, 86, 91, 94, 95; Upper Estuarine Clay, 99; Fullers' Earth, 100; Great Oolite, 116-120.
Coombehillhead Rookery, 87.

Coscombe Quarry, 56.
Cotswold Slate Pits (Eyford), 115, 116.
Cotteswold Sands, 27, 28, 30.
Creddiford Brook, 56.
Cutsdean, 90.
Cutsdean Hill Barn, 61.

Devonport Wood Quarry, 91.
Diamond Laundry Well (Charlton Kings), 124.
Didcot Farm Brick Works (disused), 14.
Dikler, River, 5, 28; gravel, 133.
Dines, H. G., 121-126, 128, 133-135.
Dinosaur remains in Chipping Norton Limestone, 88.
Ditchford Hill, superficial, 128, 129.
Dixton Hill, 26.
Donnington, *see* Stonehill Quarry.
Dorn, superficial, 131.
Double, I. S., 94.
Dovedale Farm, 68.
Downwash Gravel, 6, 121.
Drainage, 4.
Dumbleton Hill, 14, 31. *See also* Alderton.
Duncan, C. C., 141.

Early Man, 136.
Evenlode River, 4, 131.
—— superficial, 132.
Evesham Road cutting, 21.
—— Vale of, superficial, 121-128, 133.
Eye, River, 5; gravel, 133.
Eyford, Stonesfield Slate, 113; Marly Beds, 117.

Far Hill Barn, 83.
'Far' Upton Wold, 70.
Farncott Wood, 55.
Faults, 10.
Fenwick's Quarry, 95.
Fish and Insect Bed, 33.
Fish Inn (Broadway Hill), 63.
Five Mile Drive Quarry, 67.
Flagstone, 86, 94, 95.
Fleet, W. F., 124, 125.
Folly Lane Brick Works, 14, 20.
Ford, 57, 60.
Fordhill Farm, 61.
Forest Marble, 120.
Fosse Way quarries and cutting, 73, 87, 88.
Fox Farm, 94, 120.
Fullers' Earth, 52, 84, 85, 98, 100, 101, 103, 106, 112, 115.

Gaut, R. C., 137-142.
Gavey, G. E., 15, 131.
Gawcombe Lodge, 83.
Geological Formations, 5.
Glacial Sand and Gravel, 128, 130.
Gotherington, superficial, 123.
Granny's Bank Coppice Quarry, 86, 97.
Gravel, unbedded limestone, 121.
Gray, J. W., 121.
Great Oolite Series (table), 85, 102-120.
—— Rissington, 82, 83.
—— Washbourne, superficial, 125, 126.
Greet, 11, 15.
Gretton, Marlstone, 25; Upper Lias, 31.
Groves Bros., Messrs., 143.
Gryphite Grit, 42.
Guise, Sir Wm. V., 126.
Guitinghill, Farm, 86, 90, 91; Quarry, 86, 91, 92, 93.
'Guiting Stone,' 60.

Ham (Charlton Kings), 25.
Hampen cutting, Fullers' Earth, 100; Great Oolite, 103-106, 110, 117, 118.
Harford Sands, 38.
Harp Hill, 13.
Hawling, Inferior Oolite, 54; Great Oolite, 108, 115.
Hayles, 123.
Heath Farm, 63.
Heaver Plantation, 61, 90.
Hinchwick, 84, 86, 90, 93, 94; Pools, 28, 71.
Holl, H. B., 44, 50.
Hollow Barn, 96.
Holt Quarry, The, 67.
Hopwood, A. T., 89.
Horn's Leazor, 71, 86, 89, 90.
Hudleston, W. H., 93, 97.
Hull, E., 28, 44, 53, 57, 71, 74, 86, 110, 118, 132-134.
Hunting Butts Tunnel, 20, 21.
Huntsman's Quarry (Naunton), 114, 115.

Hutton, Mrs., 14, 31.
Hyatt's Pits, 89, 90.

Iccomb District, Inferior Oolite, 82, 83; superficial, 134.
Industries, 2.
Inferior Oolite, 35; subdivisions, 36.
Isbourne, River, 5, 128.

Jackdaw Quarry (Stanway), 56.
Jones, T. Rupert, 112.

Kineton, 60; Kineton Thorns, 113.
Kinetonhill Farm, 86, 94, 104.
Knee Brook, pre-Glacial gravel, 128, 131, 133.

Landslips, 135, 136.
Lang, W. D., 11, 17.
Langley Hill, 52.
Lapstone Farm, 65, 66.
'Ledmores,' 12.
Leighswood, 15.
Lias, Lower, 11-24, 123, 132; of Cheltenham and Radstock compared, 22, 23; Middle, 23-27; Upper, 27-34.
Lime, 147.
Lime Hill Wood, 54, 87.
Limonite in Oolite, 94.
Ling Ground, 86.
Longborough, 89; Quarry, 72.
Lower Freestone, 37.
—— Lemington, boring, 6, 9; superficial, 131.
—— Limestone, 37.
—— Slaughter, 59; superficial, 132, 133.
—— Swell, 95, 117.
—— Trigonia Grit, 41.

Mammalian remains, 125, 126.
Marefurlong, superficial, 131.
Marle Hill Brick Works, *see* Folly Lane.
Marlstone, 23.
Marly Beds, 102, 103, 117.
Martin's Hill, Chipping Norton Limestone, 86, 87; superficial, 87, 134.
Mickleton boring, 7, 9.
Millhampost, 123.
Moreton, anticline, 7, 30, 35, 101, 102, 104, 113.
—— Vale of, superficial, 128-133.
Murchison, Sir Roderick I., 106.

Naunton, 57, 58, 98, 113, 114; Clay, 39, 57, 60.
Neaeran Beds, 88, 97, 99.
New Buildings, 115, 116.
Newpark Quarry, 86, 89.
'Northern Drift,' 133, 134.
Notgrove, 75, 78, 110; Freestone, 42.
Noverton (Prestbury), superficial, 31, 121, 123.

Oat Hill (Snowshill), 61.
Oddington, 16, 26, 31, 99.
Oolite Marl, 37.
Ostrea acuminata Limestones, 102, 103, 105-110.
Overbury, 14, 33, 44; superficial, 125, 126, 128.
Oxenton Hill, 24, 26, 49.

Paxford, superficial, 128-131.
Pea Grit Series, 35.
Physical Features, 4.
Piece Quarry, 62.
Pinnock, 31, 56.
Polyzoa Bed, 50.
Prestbury, superficial, 123, 124.
Puckham, Upper Lias, 31; Inferior Oolite, 49.

Queen's Wood Cottages (Prestbury), 14.

Rhynchonella -Bed, 102, 105-110, 114, 117.
Rivers, 4, 5; development, 128, 133.
River Gravel, 121, 128, 132; Pre-Glacial, 128.
'Roadstone Hole,' 50.
—— Quarry, 69.
Road metal, 148, 149.
Roel, 54, 55, 148.
Rolling Bank Quarry, 52.

Roundhill, cutting, 97, 112; Clay, 82-85, 88, 113; Farm, 98.
Ryeworth, 124.

Salperton Downs, 107-111, 115, 116.
Salter, A. E., 133.
Sand used for commercial purposes, 147.
Sandy Beds, 23.
Sandywell Park, 30.
Sarsenstone at Black Downs, 130.
Scarborough, 61, 90.
Scenery, 8.
Scissum Beds, 35.
Sedgeberrow, 125, 126, 128.
Seven Wells (Broadway), 63.
Sevenhampton, 54, 106-108; Marl, 105, 107, 108, 114.
Sezincote, 73; Hill, 72.
Shakell's Pike, 13.
Sherborn, C. D., 112.
Skerl, J. G. A., 28, 68.
Slate Barn boring, 70.
Slate pits, Upper and Lower, 90.
Slatter, T. J., 15.
Smallthorns, 71, 89.
Snowshill, 61, 62, 84, 86, 90; Clay, 39; Hill, 71, 89.
Soils, analyses, 141.
Spath, L. F., 11, 17.
Springhill, 62, 63, 71.
Standles Coppice, 95.
Stanton Fields cutting, 20, 23.
Stonehill Quarry (Donnington), 87, 89, 111, 113, 117.
Stonesfield Slate Series, 86, 102, 104-116; fossils, 114; 'slats,' 145, 146.
Stow on the Wold, 30, 73, 86, 88, 113; superficial, 74, 131, 132, 134; waterworks' well, 73.
Straits Quarry, 55.
Stretton on Fosse, superficial, 130-132.
Strickland, H. E., 44, 106.
Sudeley Hill, 54.
Summerhill, 113, 118.
Superficial Deposits, 121-135.
Sutcliffe, R., 148.
Symonds, Rev. W. S., 126.
Syreford, 121, 135.

Tate, R., 15.
Taynton Stone, 78, 85, 102, 105, 110-113, 117.
Tectonic structure, 6.
Temple Guiting, 56, 86, 91, 116.
Thomas, H. H., 124.
Tilestone, 40.
Tile-stones, 144-146.
Toddington, 8, 15.
Tomes, R. F., 93, 110.
Town Quarry, 59.
Trafalgar, 61.
Trueman, A. E., 11, 16.
Tulophorites aff. *tulotus* S. S. Buckman in White Limestone, 119.

Uplands, 'Northern Drift' pebbles on, 133, 134; glaciation, 134, 135.
Upper Estuarine Clay, 52-54, 75, 76, 84, 87, 88, 90-93, 97-101.
—— Freestone, 38.
—— Slaughter, 59, 86.
—— Swell, 94.
—— Trigonia Grit, 43.

Valleys, origin of coombe-like, 135.

Wagborough Bush, 59, 104.
Walford, E. A., 32, 82, 97, 110, 112, 113.
Warren Farm, 71, 73.
Water Supply, 149-155.
Welch, F. B. A., 60, 67, 88, 89, 91, 95, 100, 116, 118, 119.
Westington Hill, 64.
Weston Subedge cutting, 19.
Wethered, E. B., 45, 48, 50.
Whitehill Farm, 108.
White Limestone, 85, 102, 118-120.
Whittington, 51.
Williams, Miss D. M., 11, 16.
Winchcomb, 87; anticline, 8; Brick and Tile Works, 11, 15.
Windrush, River, 4; gravel, 133.
Witchell, E., 32, 77.
Witchellia Grit, 42.
Wood Farm, 56.
Woodward, Sir Arthur Smith, 89.
Woodward, H. B., 15, 16, 27, 30, 32, 44, 63, 64, 69, 72, 78, 88, 102, 106, 110, 117, 118, 143, 146.
Wormington, superficial, 125, 126, 128.
Wright, T., 13-15, 31, 32, 54.
Wyck Rissington, 16, 83.

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